BALLARD MINE FEASIBILITY STUDY REPORT

MEMORANDUM 1 SITE BACKGROUND AND SCREENING OF TECHNOLOGIES

FINAL REVISION 2

Ballard Mine Site

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amsl	above mean sea level
ARARs	applicable or relevant and appropriate requirements
A/Ts	Agencies and Tribes
bgs	below ground surface
BLM	Bureau of Land Management
BRA	Baseline Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
CO/AOC	Consent Order/Administrative Order on Consent
COC	contaminant of concern
COEC	contaminant of ecological concern
COPC	contaminant of potential concern
COPEC	chemical of potential ecological concern
CWA	Clean Water Act
cy	cubic yard
DAR	Data Approval Request
ºF	degrees Fahrenheit
DQUR	Data Quality and Usability Report
EE/CA	Engineering Evaluation and Cost Analysis
EIS	Environmental Impact Statement
ERA	Ecological Risk Assessment
ET	evapotranspiration
FS	Feasibility Study
ft	feet
GRA	general response action
gpm	gallons per minute
HHRA	Human Health Risk Assessment
HI	hazard indices
HQ	hazard quotients
IC	institutional controls
ICCDB	Idaho Conservation Center Data Base
IDEQ	Idaho Department of Environmental Quality
ILCRs	incremental lifetime cancer risks
IMA	Idaho Mining Association
ISTD	in-situ thermal desorption
LCOC	livestock contaminants of concern
LCOPC	livestock contaminants of potential concern
LRA	livestock risk assessment
LUC	land use controls
MCL	maximum contaminant level (i.e., Federal drinking water standard)
MCY	million cubic yards

mg/kg	milligrams per kilograms
mg/L	milligrams per liter
MDS	Monsanto dump seep monitoring location (e.g., MDS030)
MMP	Monsanto mine pit (e.g., MMP041)
MMW	Monsanto monitoring well location (e.g., MMW022)
MNA	monitored natural attenuation
MNR	monitored natural recovery
MSG	Monsanto spring monitoring location (e.g., MSG003)
MSP	Monsanto pond monitoring location (e.g., MSP055)
MST	Monsanto stream monitoring location (e.g., MST062)
MWD	Monsanto waste rock dump (e.g., MWD090)
MW	Montgomery Watson (predecessor to MWH)
MWH	MWH, Inc. (formerly Montgomery Watson Harza, Inc.)
NCP	National Contingency Plan
NPDES	National Pollutant Discharge Elimination System
NRWQC	National Recommended Water Quality Criteria
O&M	operations and maintenance
OSWER	Office of Solid Waste and Emergency Response (USEPA)
P4	P4 Production, L.L.C.
PCL	preliminary cleanup level
POTW	publically owned treatment works
PRB	Permeable Reactive Barrier
RA	remedial action
RAO	remedial action objective
RBCL	risk-based cleanup level
RD	remedial design
RI	Remedial Investigation
RI/FS	Remedial Investigation and Feasibility Study
RME	reasonable maximum exposure
ROC	radionuclide of concern
ROD	record of decision
S/S	stabilization/solidification
SE	southeast (e.g., SE Idaho)
SI	Site Investigation (as in part of the EE/CA)
Site	P4 Ballard Site
SOW	Statement of Work (from the RI/FS AOC unless specified otherwise)
SVE	soil vapor extraction
TBC	to be considered
TDS	total dissolved solids
UIC	underground injection control
USEPA	United States Environmental Protection Agency

USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USL	upper simultaneous limit
UTL	upper tolerance limit

1 INTRODUCTION

1.1 PURPOSE

In 2009, P4 Production, L.L.C. (P4) entered an Administrative Settlement Agreement and Order on Consent/Consent Order (2009 CO/AOC; USEPA, 2009a) with the United States Environmental Protection Agency (USEPA); the Idaho Department of Environmental Quality (IDEQ); the United States Department of Agriculture, United States Forest Service (USFS); the United States Department of the Interior including the Bureau of Land Management (BLM) and Fish and Wildlife Service (FWS); and the Shoshone-Bannock Tribes (Tribes), collectively referred to as the Agencies and Tribes or A/Ts. The general objective of the 2009 CO/AOC was to conduct a remedial investigation and feasibility study (RI/FS) of P4's legacy mine sites, the oldest of which is Ballard Mine (Ballard Site). With A/T concurrence, P4 is performing this work sequentially, starting with the Ballard Site and then moving onto the newer legacy mine sites. In 2014, P4 completed the RI for the Ballard Site, which is summarized in the *Ballard Mine RI Report – Final Revision 2* (*Ballard Mine RI Report;* MWH, 2014). The Ballard Mine FS is being summarized in two memoranda and this submission (Ballard FS Memorandum #1) is the first of two that will together comprise the FS for the Ballard Site.

According to Appendix 1 Statement of Work (SOW), Task 5.a of the 2009 CO/AOC, the general objective of the FS is to determine and evaluate alternatives for remedial action (RA), if any, to prevent, mitigate, or otherwise respond to, or remedy, any release, or threatened release, of hazardous substances, pollutants, or contaminants at or from the Site. More particularly, the purpose of the FS first, is to assemble and screen remedial technologies for the identified contaminants of concern (COCs), radionuclides of concern (ROCs), contaminants of ecological concern (COECs), and livestock contaminants of concern (LCOCs) in each environmental medium and second, use the selected technologies to create and evaluate remedial alternatives, in this case, for the Ballard Site.

This Ballard FS Memo #1 addresses the first objective by identifying and evaluating available remedial technologies. The second technical memorandum (Ballard FS Memo #2) will address the second FS objective by assembling, screening, and comparing a wide variety of possible remedial alternatives.

This Ballard FS Memo #1 summarizes the key findings of *Ballard Mine RI Report* and the *Baseline Risk Assessment (BRA* - presented in Appendix A of the *Ballard Mine RI Report*). This memorandum then presents applicable or relevant and appropriate requirements (ARARs), remedial action objectives (RAOs), general response actions (GRAs), and preliminary cleanup levels for the Ballard Site. It evaluates available technologies for each medium against the RAOs, GRAs and preliminary cleanup levels, with an initial screening based on their technical implementability, followed by a second more detailed screening of their effectiveness, implementability, and cost. These two screening steps ensure that only the viable technologies for each medium are used in the assembly of remedial alternatives presented in Ballard FS Memo #2.

Ballard FS Memo #2, which P4 will submit following A/T concurrence with the Ballard FS Memo #1, will assemble and screen a range of alternatives by effectiveness, implementability, and cost. This initial screening will be followed by a detailed screen (analysis) using the seven CERCLA threshold and balancing criteria (USEPA, 1988a). Ballard FS Memo #2 also will present a comparative analysis of the medium-specific alternatives, combining them ultimately into a single, holistic remedial alternative for USEPA concurrence.

Alternatives for specific media and particular areas within the Site either can be carried through the FS process separately or combined into comprehensive alternatives for the entire site. The approach is flexible and allows the alternatives for the media to be combined at various points in the process. In this case, because of the number of media involved in the process (i.e., waste rock/soil, sediment/riparian soil, vegetation, surface water, and groundwater), remedial alternatives are developed and fully screened by medium, and then combined toward the end of the process in Ballard FS Memo #2.

1.2 DOCUMENT ORGANI ATION

This Ballard FS Memo #1 generally follows the suggested outline in *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final* (*RI/FS Guidance*; USEPA, 1988a) and consists of six sections and two appendices:

Section 1.0 Introduction

Section 2.0 Principal RI/BRA Findings and COCs/ROCs/COECs

Section 3.0 Remedial Action Objectives, Applicable or Relevant and Appropriate Requirements (ARARs), General Response Actions and Preliminary Cleanup Levels

Section 4.0 Technology Identification and Initial Screening – Identifies and screens a wide range of potentially usable technologies and process options for remediation of each of the contaminated Site media with respect to technical implementability.

Section 5.0 Final Screening of Remedial Technologies – Screens the remaining remedial technologies for each of the contaminated Site media with respect to effectiveness, implementability, and cost to eliminate marginal technologies and identify potentially feasible (or viable) technologies for remediation of the Ballard Site.

Section 6.0 References

Appendix A Development of Risk-Based Cleanup Levels for Soil and Sediment - Ballard Site

Appendix B Details of Final Remedial Technology Screening

Appendix C Comments and Comment Responses

1.3 SITE BACKGROUND SUMMARY

This subsection provides a summary of the Ballard Site physical condition, operational and regulatory history, and history of environmental investigation. A more detailed description of the Site conditions and history is presented in the *Ballard Mine RI Report*.

1.3.1 Site Description

The Ballard Mine is located approximately 13 miles north-northeast of Soda Springs, Idaho in Caribou County (**Drawing 1-1**) and is accessed via the Blackfoot River Road, off of State Highway 34. The Ballard Mine is comprised of external mine waste dumps, open pits, an abandoned haul road, and the Ballard Shop Area, all of which cover approximately 534 acres of disturbance. P4 owns approximately 865 acres of surface rights and has a surface easement from the State of Idaho on an additional 360 acres. These properties contain all of Ballard Mine (**Drawing 1-2**). The adjoining properties are all privately held ranching and farming properties. The nearest downstream Federal land is a 40 acre BLM parcel approximately one mile southeast of the Site.

Ancillary facilities remaining at the Ballard Mine include remnants of a partially paved haul road, various unimproved soft surface two-track roads, and the Ballard Shop Area consisting of a large garage/shop building, various small storage sheds and buildings, and a stockpile of slag from the P4 Soda Springs plant (see **Drawing 1-3**). A small office building was demolished in 2011.

Ballard Shop Area – This area was investigated in 2010 to assess the potential for upland soil and groundwater contamination sources associated with organic compounds used and stored during its operating history as a maintenance facility. As further discussed in the *Ballard Mine RI Report* and in Section 2.3.1 of this report, several volatile and semi-volatile organic compounds were detected in the Ballard Shop Area soil and groundwater. As a result, the Ballard Shop Area will not be addressed further in this FS for the overall Ballard Site because it is the only isolated area of the Site that:

- Has organic contamination requiring a different suite of treatment technologies and assembled alternatives from the metals/metalloids for the vast majority of the Site;
- Is currently being operated as an industrial facility with ongoing use; and,
- Will be addressed, as instructed by USEPA, in a separate closure plan describing: 1) the Ballard Shop background, i.e., the nature and extent of contamination and technologies suitable for remediation of the Shop constituents, 2) plans for control of risks to industrial workers during future industrial use of the area prior to final closure, 3) plans for control of any ongoing contamination from source area(s) identified at the Ballard Shop and 4) plans for final closure of the Ballard Shop when the area is no longer used. This plan will be developed prior to the finalization of Final FS Memo #2 so that the Ballard Shop Area can be included in the ROD for the overall Site.

It should be noted that the Ballard Shop Area has both inorganic (the slag pile) and organic contamination and that final Site deposition as described in Ballard Shop Area closure plan discussed above may change in the future as organic contaminants naturally degrade and the slag pile is removed through use on roadways.

1.3.2 Ballard Mining History

Ballard Mine, located in T7S, R42-43E, is the oldest of the three phosphate mines being addressed in the P4 Sites RI/FS. Exploration and stripping at the mine began in June 1951, full-operation mining activities started in 1952, and mining activities ceased in 1969. During the 17 years of mining, several side-hill and open-pit excavations produced 10.4 million dry net tons of phosphate ore which were hauled to the Monsanto elemental phosphorus plant at Soda Springs (Lee, 2001). Approximately 20 million cubic yards (MCY) of waste rock were stripped; of that amount, two MCY were used to backfill the pits, with the remaining 18 MCY hauled to the mine waste dumps (Lee, 2001). The Ballard Mine mineral leases were relinquished to the BLM in April 1984, and BLM accepted relinquishment in July 1984. P4 Production, L.L.C, which was formed in 1997, has responsibility for the Ballard Mine.

1.3.3 Regulatory History

Investigations to assess potential impacts of phosphate mining in SE Idaho on human health and the environment began in 1996. Overburden and waste rock, which are byproducts of extracting phosphate ore from the earth, have the potential to release selenium to the environment at levels that exceed background levels.

During the early years of investigation, the majority of the regional investigations were conducted under direction of the Idaho Mining Association's (IMA's) Selenium Committee. Regulatory agencies provided input and some oversight through the Interagency/Phosphate Industry Selenium Working Group. In 2001, the regional investigation was transformed into an area-wide investigation performed by several phosphate mining companies belonging to IMA (Selenium Area-Wide Advisory Committee) under the direction of IDEQ and other regulatory agencies pursuant to a CERCLA CO/AOC (2001 CO/AOC; IDEQ, 2001).

In 2004 the investigations began to focus on specific mines in the region, including the P4 Sites. Effective October 24, 2003, the USEPA, IDEQ, USFS, and P4 entered into a new CO/AOC (2003 CO/AOC; USEPA, 2003). The 2003 CO/AOC, under IDEQ lead, provided for the performance of Site Investigations (SIs) and EE/CA programs for the P4 Ballard, Henry and Enoch Valley Sites that were consistent with Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).

In 2009, at the request of USEPA, P4 and the A/Ts entered a new CO/AOC obligating P4 to perform an RI/FS and superseding the 2003 CO/AOC.

1.3.4 Previous Investigations

Several studies have been conducted since 1996 at and near the Ballard Site to assess the nature and extent of impacts from phosphate mining. These studies are listed chronologically in Section 1.0 of the *Ballard Mine RI Report* with only notable investigation and study reports listed below. Much of the investigative data associated with the Ballard Site have been collected to evaluate potential impacts from mining, with emphasis on selenium in the environment. A number of studies are mentioned for historical context with recognition that older data and data collected at other P4 and regional phosphate mining sites may provide insight into fate and transport behavior of primary constituents at the Ballard Site.

Most of the pre-2003 CO/AOC data and study summaries are presented in various reports given to either the IMA or P4 and are available in the public record. All of the post-2003 AOC data have been validated by procedures prescribed by the A/Ts.

1998-2001

- Regional Investigation Data Summary Reports (MW, 1998-2001b)

2002

- Area Wide Investigation Data Summary Reports (MWH, 2002a and 2002b)
- Final Area Wide Human Health and Ecological Risk Assessment, Selenium Project, Southeast Idaho Phosphate Mining Resource Area (Tetra Tech, 2002)

2004

- Area Wide Risk Management Plan: Removal Action Goals and Objectives, and Action Levels for Addressing Releases and Impacts from Historic Phosphate Mining Operations in Southeast Idaho (IDEQ, 2004a)

2007

- Interim Phase I SIs Evaluation Summary (MWH, 2007)

2008

- Interim Report for Hydrogeologic Investigation Revision 3 – 2007 Hydrogeologic Data Collection Activities & Updated Conceptual Models (MWH, 2008)

2010

- Data Quality and Usability Report (DQUR) and Data Approval Request (DAR) – Final, Revision 2 (MWH, 2010a)

2011

- Remedial Investigation/Feasibility Study Work Plan for P4's Ballard, Henry and Enoch Valley Mines. (MWH, 2011)

2012

- Ballard, Henry, and Enoch Valley Mine, Remedial Investigation and Feasibility Study, Background Levels Development Technical Memorandum (MWH, 2013)

2014

- Remedial Investigation Report for P4's Ballard Mine (MWH, 2014)

2015

- On-Site and Background Areas Radiological and Soil Investigation Summary Report (MWH, 2015a)

1.4 SUMMARY OF PHYSICAL CHARACTERISTICS

This section summarizes the regional and Site-specific physical characteristics and includes (1) physiography, (2) surface features, (3) climate and meteorological information, (4) surface water hydrology, (5) geology, (6) hydrogeology, (7) ecology, and (8) demographics and land use. Detailed specifics for each of these categories as well as for soils and cultural and natural resources are presented in the *Ballard Mine RI Report*.

1.4.1 Physiography

Topography of the Ballard Site is dominated by a medium gradient, north-northwest/south-southeast trending ridgeline at elevations ranging from approximately 6,300 to 7,000 feet above mean sea level (amsl) (**Drawing 1-3**). Away from the ridgeline to the east and west, the Ballard Site is bounded by three relatively low-gradient drainage basins containing a number of intermittent/ephemeral streams that originate from, or flow past, the Site. The Site is located within three drainages: Long Valley Creek, Wooley Valley Creek, and the Blackfoot River as shown on **Drawing 1-4**.

The Ballard Mine encompasses approximately 535 acres of mine waste dumps, mine pits and service areas. Due to the age of the mine, vegetation has developed over most of the mine area with the exception of some mine pit areas and a few steep mine waste dump slopes. The configuration of the mine pits and mine waste dump areas at the Ballard Site are shown on **Drawing 1-3**.

1.4.2 Surface Features

Lands adjacent to the Ballard Site are agricultural, with grazing to the east and cultivated fields to the west. Natural topography dominates the landscapes adjacent to the Ballard Site.

Mine Pits and Mine Waste Dumps. The configuration of the mine waste rock dumps and pits is shown on **Drawing 1-3**. There are six mine pits at the Ballard Site. The largest pits are MMP035 (the West Ballard Pit) and MMP036 (Central Ballard Pit) located on the western edge and in the central portion of the Ballard Site, respectively. Three smaller pits, MMP037, MMP039 and

MMP040 are located in the eastern portion of the Ballard Site. The MMP038 pit is a small closed pit located south of the mine features.

There are six mine waste rock dumps at the Ballard Site – MWD080, MWD081, MWD082, MWD083, MWD084, and MWD093. The mine waste rock dumps at the Ballard Site are generally flat topped with angle of repose outer slopes. Waste rock was also placed in mine pits MMP035 and MMP036. The areas and volumes of mine wastes are provided in Section 4.1.

Ancillary Facilities. At this time, the only ancillary facilities remaining at the Ballard Mine are remnants of a partially paved haul road, various unimproved soft surface two-track roads, and the Ballard Shop Area consisting of a large garage/shop building, various small storage sheds and buildings, and a stockpile of slag from the P4 Soda Springs plant. This stockpiled slag is being used for maintenance on haul roads and associated facilities consistent with accepted uses on P4's plant site and other P4 facilities per the 1996 P4 Soda Springs Plant's AOC (further discussed in Section 2.2.2 of the *Ballard Mine RI Report).*

Surface Cover Materials and Vegetation. Based on the 2009 upland soil and vegetation investigation, surficial material on mine waste dumps at the Site consists mainly of an approximate 2:1 mixture of weathered brown shale and black shale. The weathered brown shale represents the weathered rock stripped from the near surface during mining to reach the ore beds of the Meade Peak Member of the Phosphoria Formation, and the black shale is typically the waste shale that was located between and immediately above and below the Meade Peak Member ore beds. Limestone and sandstone typically are found at or near the base of Wells Formation highwalls. Dolomite or limestone boulders are present primarily near the edges of highwalls and pits.

The vegetative cover is relatively dense in some areas consisting mainly of grass and forbs species and with other areas possessing a higher percentage of woody species. The following species are the most common:

- *Pascopyrum smithii:* western wheatgrass
- *Dactylis glomerata*: orchardgrass
- *Bromus tectorum*: cheatgrass
- *Bromus inermis*: smooth brome
- *Medicago sativa*: alfalfa

- *Achillea millefolium*: western yarrow
- *Geranium viscosissimum*: sticky geranium
- *Lappula occidentalis*: flatspine stickseed
- *Amelanchier alnifolia*: serviceberry
- *Artemisia tridentata*: big sagebrush
- *Populus tremuloides*: quaking aspen
- *Purshia tridentata:* antelope bitterbrush

The vegetation at the Ballard Mine is a combination of planted (shrub and trees) and seeded (e.g., alfalfa), along with volunteer vegetation from seeds blown in from the surrounding area.

Several steep slopes, primarily highwalls and angle-of-repose slopes in the southern portion of the Ballard Site, are unvegetated. Detailed information on the soil and vegetation surveys conducted in 2009 can be found in the Appendix A2 of the *P4 Sites RI/FS Work Plan*. The vegetation cover was subsequently altered in 2012 by a rangeland fire. The vegetation in portions of the Ballard Site, including parts of MMP035, MWD080, MWD093, and MMP036, were burned.

1.4.3 Climate and Meteorological Information

The climate of southeast Idaho is semi-arid with hot summers and cold winters. The climate is strongly influenced by topography, which in turn influences wind patterns, temperature, and precipitation. North-south trending mountain ranges in the region create a natural barrier for water-saturated Pacific air masses. The rain-shadow effect causes the Snake River Plain region to be semi-arid with a middle latitude steppe climate. Precipitation during the colder months is generally in the form of snow, while precipitation during the summer is primarily associated with localized, orographic thunderstorms. Meteorological data are not available directly from the Ballard Site. However, meteorological data are available for the nearby Blackfoot Bridge Mine. The data collected suggests that the average annual precipitation in the Ballard Site vicinity is on the order of 13 inches per year over a 9.5-year period. However, analysis conducted for the Blackfoot Bridge EIS suggests the longer-term average for the Blackfoot Bridge/Ballard Site area may be upward of 17 inches per year (BLM, 2011). Based on the Blackfoot Bridge meteorological data, July and August are the warmest months of the year, while December and January are the coldest. Average temperatures range from average minimums of 7.9 degrees Fahrenheit (ºF) in December to average maximums of 80.9ºF in July.

1.4.4 Surface Water Hydrology

The Ballard Site is a headwater area with small, generally intermittent/ephemeral streams flowing towards larger drainages off-Site. Most of the headwater streams in the area only flow during snowmelt runoff. However, a few streams are fed by perennial springs that only flow for a short distance before infiltrating. These streams then typically are dry downstream of the infiltrating spring water.

Streams. The small drainages originating from the Ballard Site flow to one of three drainage basins adjacent to the Ballard Site: Long Valley Creek, Wooley Valley Creek, and the Blackfoot River (**Drawing 1-4**). Long Valley Creek leads generally northward to the Little Blackfoot River, which flows into the Blackfoot Reservoir. The northwest corner of the Ballard Site is a headwater area for the Long Valley Creek drainage. However, the Ballard Site contributes very little flow to this drainage and monitoring locations with measureable flow to the drainage have not been identified on Site. Long Valley Creek is monitored downstream of the Ballard Site.

The Ballard Site is in a headwater area of Wooley Valley Creek, and Wooley Valley Creek is the primary drainage along the eastern edge of the Site. Wooley Valley Creek reaches the Blackfoot River during the snowmelt and peak runoff periods in the spring, but is often dry in the summer and does not contribute significant flow to the Blackfoot River for the rest of the year. Influences by other (non-P4) phosphate mining operations could possibly impact the lower reaches of Wooley Valley Creek.

The Blackfoot River is located south of the Ballard Site and surface water from the southwestern corner of the Ballard Site flows directly towards the Blackfoot River located approximately one mile to the south at its nearest point. Three minor drainages combine just southwest of the Ballard Site to form a single drainage that enters the Blackfoot River. This drainage does not have a formal name, but has informally been called Ballard Creek in the past. Monitoring station MST066 is located on this drainage just below the confluence of the three minor drainages.

Ponds. Six small ponds (one closed) are present on the Ballard Site. These pond locations are shown on **Drawing 1-3**. A majority of these ponds are seasonal and are dry by late summer. They vary in size from less than 0.1 acres (MSP059) to approximately 0.21 acres (MSP062) and have varied riparian vegetation and vegetation densities surrounding them. Some have riparian habitats dominated by willows suited for some wildlife; whereas, MSP013 is a barren depression that is often dry, with no significant riparian vegetation. Stock pond MSP010 was fenced off and backfilled by P4 in 2010 and replaced with an agricultural well located to the north of the Ballard Site.

1.4.5 Geology

The Ballard Site is located nearly on the boundary between the Basin and Range and Rocky Mountain Physiographic Provinces, and the geology in the Ballard Mine area is transitional between these provinces. **Drawing 1-5** depicts the surficial geology at and adjacent to the Ballard Mine. The geology of the area is characterized by linear, north-south trending, fault-bounded ranges and basins formed by extensional tectonism. This extensional tectonism overprints an earlier period of compressional tectonics that included major overthrusting, which resulted in synclinal-anticlinal folds and some faulting during the Upper Cretaceous and Paleocene periods.

Ranges in southeast Idaho are generally composed of deformed Paleozoic and Mesozoic sedimentary rocks, including thick marine clastic units, cherts, and limestones. The valleys are largely filled in with Quaternary alluvium and colluvium that overlie Pleistocene basalt flows in some places. Thick basaltic flows of the Snake River Plain region and rhyolite domes south of the Blackfoot Reservoir and west of the Ballard Site comprise most of the remaining volcanic sequences in the region. Massive accumulations of marine sediment occurred during the Paleozoic era over a large area of eastern Idaho, southwestern Montana, and northern Utah. During Permian times the Phosphoria Formation was deposited, creating the western phosphate field which includes the SE Idaho phosphate resource area. The Phosphoria Formation has four members (from oldest to youngest): the Meade Peak Phosphatic Shale, Rex Chert, Cherty Shale, and Retort Phosphatic Shale. The Meade Peak Member, which ranges in thickness from about 55 to 200 feet, is the source of most of the extracted phosphate ore. This is the oldest member of the Phosphoria Formation and is typically overlain by either the Rex Chert or the Cherty Shale. The Retort Member is discontinuous and is found in the northern and eastern parts of the region but not in the vicinity of the Ballard Site (USGS and USFS, 1977).

Another significant sedimentary unit in the area is the Triassic Dinwoody Formation, which is made up of upper and lower units consisting of limestone, siltstone, and shale layers. The lower Dinwoody Formation directly overlies the Phosphoria units in the stratigraphic section. The upper and lower units are often separated by a distinct layer of Woodside Shale.

The Meade Peak Member of the Phosphoria Formation is underlain by the upper unit of the Wells Formation, which consists of sandstone interbedded with limestone and dolomite. In some locations, the Grandeur Limestone of the Park City Formation is present above the Wells Formation and is usually considered part of the Wells Formation for mapping purposes.

1.4.6 Hydrogeology

The groundwater system in the region can be divided into (1) local shallow groundwater systems within basin-fill alluvium, (2) shallow to deep intermediate systems within sedimentary bedrock units, and (3) regional groundwater flow systems within deeper sedimentary bedrock units. Local systems generally are recharged and discharge within a single adjacent ridge and valley area. An example of an intermediate flow system is one that is recharged on one side of a ridge and then discharges to an adjacent valley; whereas, regional systems may transmit groundwater over large distances through multiple interconnecting valleys.

The alluvium and colluvium in the valleys can be up to approximately 150 feet thick and are recharged by direct precipitation and shallow flow from the topographic high points (i.e., the area ridges). The alluvial flow system is generally unconfined and may interact directly with the local surface water systems in the valleys with gaining and losing sections of streams at different locations. This is characteristic of the alluvial valley on the east side of the Ballard Site. Where the bedrock sedimentary units contact alluvium, groundwater will similarly move between the alluvium and bedrock depending on the hydraulic characteristics of the units and the hydraulic gradients at different locations.

In the bedrock units, the Dinwoody, Phosphoria, and Wells Formations are the principal sedimentary formations in the area of the Ballard Site through which significant groundwater flow may occur. Previous hydrogeologic research conducted in the area generally indicates the following regarding potential bedrock groundwater systems in the area:

- The Dinwoody Formation typically support intermediate groundwater flow systems (Ralston et al., 1977; Ralston et al., 1980).

- The Phosphoria Formation does not support any major groundwater flow systems; however, the Rex Chert Member may transmit groundwater where locally fractured (Ralston et al., 1977; Ralston et al., 1980). The main ore-bearing unit of the Phosphoria Formation, the Meade Peak Phosphatic Shale, is relatively impermeable due to low vertical hydraulic conductivity (Ralston et al., 1980).

- The Wells Formation supports a regional groundwater system (Ralston et al., 1977; Ralston et al., 1980). The Wells Formation has the highest hydraulic conductivity compared to the other bedrock units in the region (BLM, 1999).

In general, the groundwater flow systems in the Dinwoody Formation are separated from the deeper Wells Formation by the low hydraulic conductivity of the Phosphoria Formation (in particular the Meade Peak Member). This causes the upper flow systems in the Dinwoody Formation to be typically local or intermediate in extent, while the lower flow system in the Wells Formation may commonly be regional.

Recharge to the bedrock units generally occurs along outcrops, particularly along topographically high ridges and flows downward, typically along the dip of the geologic beds. Groundwater flow through bedrock units is controlled by several factors, including the hydraulic properties of the units (i.e., with bedding and cross bedding hydraulic conductivities) and hydraulic gradients, the areal extent, thickness and orientation of the geologic units, as well as structural controls such as folding, fracturing, and faulting. The bedrock at the Ballard Site is extensively faulted with high angle faults creating numerous fault blocks that may be hydrogeologically isolated.

1.4.7 Ecology

This section briefly discusses the biological resources in the Southeast Idaho Phosphate Resource Area extracted from Tetra Tech (2002). The *1998 Regional Investigation Report* (MW, 1999) also presents a detailed discussion of the regional ecology.

The vegetation in the Southeast Idaho Phosphate Resource Area, where the Ballard Site is located, is transitional between the Great Basin vegetation to the south and the Rocky Mountain vegetation to the north (MW, 1999). The six vegetation types within the Southeast Idaho Phosphate Resource Area are a result of elevation, moisture, temperature, soil type, slope, and aspect. Based on previous investigations, the Southeast Idaho Phosphate Resource Area contains or supports about 75 species of mammals, 272 species of birds, 16 species of reptiles, 16 species of fish, and seven species of amphibians (USGS and USFS, 1977; USFWS 1985, 1997; and Idaho Conservation Center Data Base (ICCDB) 1999, all as cited in MW, 1999).

The only threatened and endangered species occurring in Caribou County is the Canada lynx (*Lynx canadensis*), listed as threatened (USFWS, 2015). In addition, it should be noted that the greater sage-grouse (*Centrocercus urophasianus*) is listed as a candidate species and could potentially occur at the Ballard Site. To date, no sightings of either species have been observed by or reported to P4.

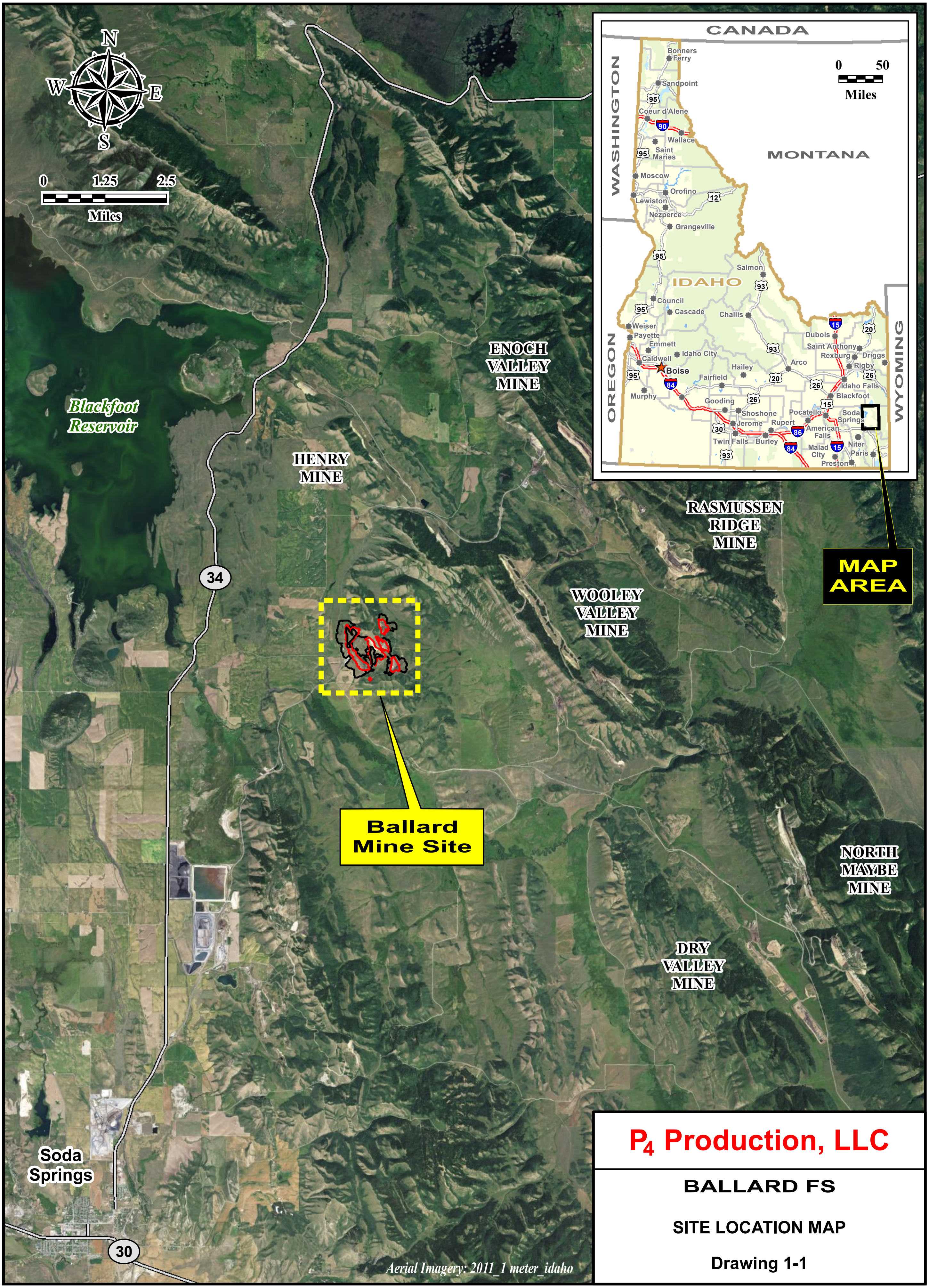
1.4.8 Demography and Land Use

The area surrounding the Ballard Site is sparsely populated. The largest nearby population center is Soda Springs, Idaho, which is located 13 miles south-southwest of the Ballard Site. The unincorporated community of Henry is located about six miles north-northwest of the Ballard Site. Outside of these areas, the population largely resides on scattered ranches and farms.

Farming and ranching are the dominant land uses in the vicinity of the Ballard Site. Farming consists of dry land crops, primarily wheat and/or barley, grown in fields to the west of the Site. Dry land crops, as the name implies, are not irrigated. Grazing is the primary land use on the adjacent properties to the north, east, and south of the Site.

Public recreation is important on the nearby state lands (see **Drawing 1-2**) and the primary public recreational use is hunting. Mining is the principal use of the area with active mining in the vicinity of the Ballard Site being conducted by P4, as well as Agrium.

Potential water resource uses in the Ballard Site area include industrial use, irrigation, stock watering, recreational use, wildlife use, and cold-water biota use. Groundwater use in the vicinity of the Ballard Site is dependent on several variables, including population and land use, availability and quality of surface water, and availability and quality of groundwater. In the valleys surrounding the mined areas, groundwater is primarily used for livestock watering, limited domestic use, and mine-site water supply



P₄ Production, LLC

BALLARD FS

SITE LOCATION MAP

Drawing 1-1

DRAWN BY D. Severson

31 Jan 2015

D:\MWH\P4 Monsanto\P4_Ballard_FS_Jan2015\FIGURES\Dwg 1-01_Ballard Mine_Site Location Map_Jan2015.mxd

DRAWN BY D. Severson

28 Jan 2015

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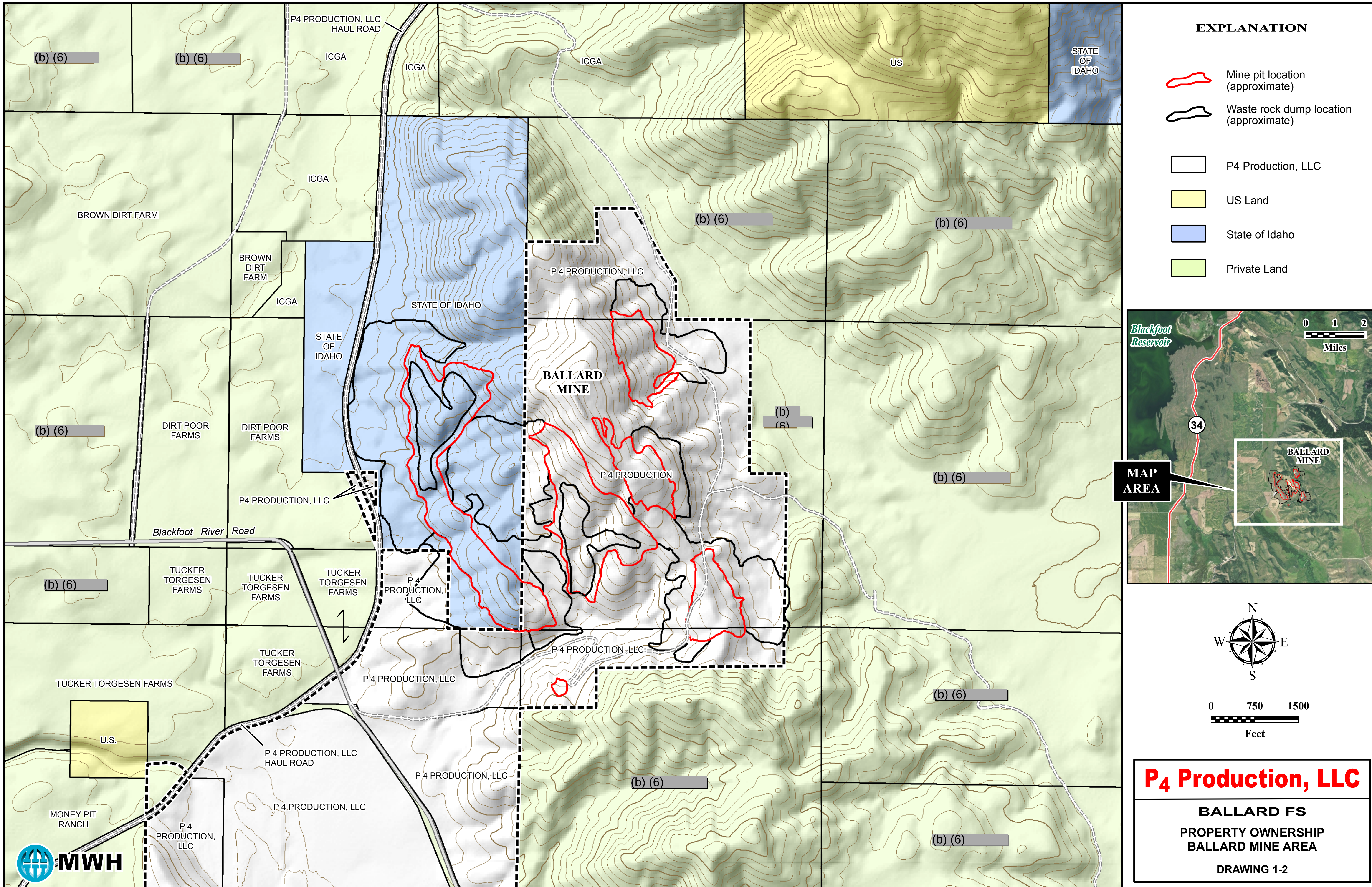
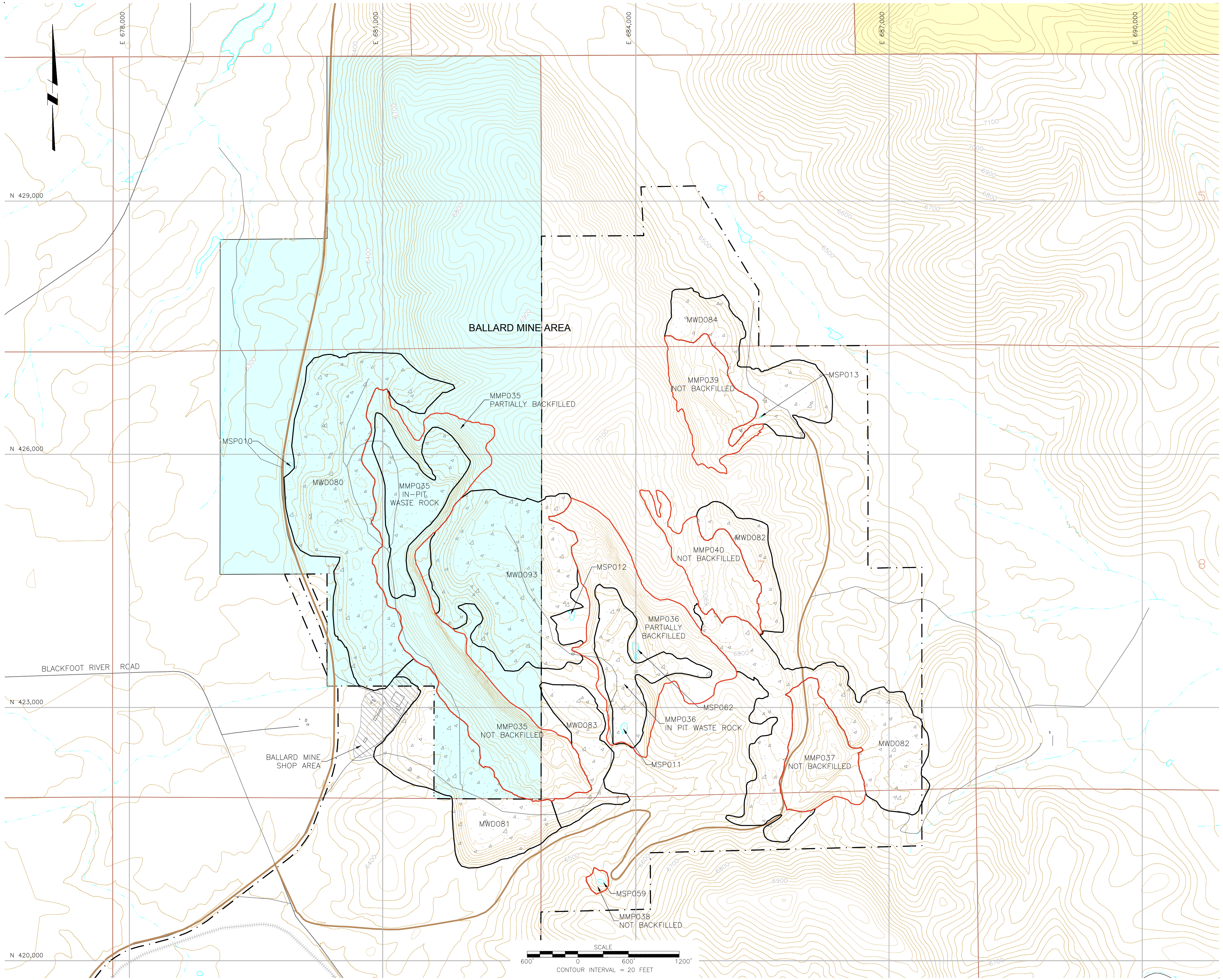




LEGEND:

- 7000 POST–MINE CONTOUR AND ELEVATION, FEET (APPROX)
- RIVER
- POND OR LAKE
- NATURAL DRAINAGE – PERENNIAL
- NATURAL DRAINAGE – INTERMITTENT
- HIGHWAY
- ROAD
- MONSANTO HAUL ROAD (ACTIVE & INACTIVE)
- RAILROAD
- MINE PIT LOCATION (APPROXIMATE WHERE COVERED BY BACKFILL)
- WASTE ROCK DUMP LOCATION (APPROX)
- WASTE ROCK DUMP LOCATION OR PIT BACKFILL (APPROX)
- P4 PRODUCTION PROPERTY BOUNDARY (APPROX)
- SECTION LINES
- A SECTION NUMBER
- BLM LANDS
- US NATIONAL FORESTS
- STATE LANDS
- OTHER PRIVATE LANDS

KEY:

MMP = MINE PIT
MWD = WASTE ROCK DUMP
MSP = POND

P_4 Production, LLC

BALLARD FS

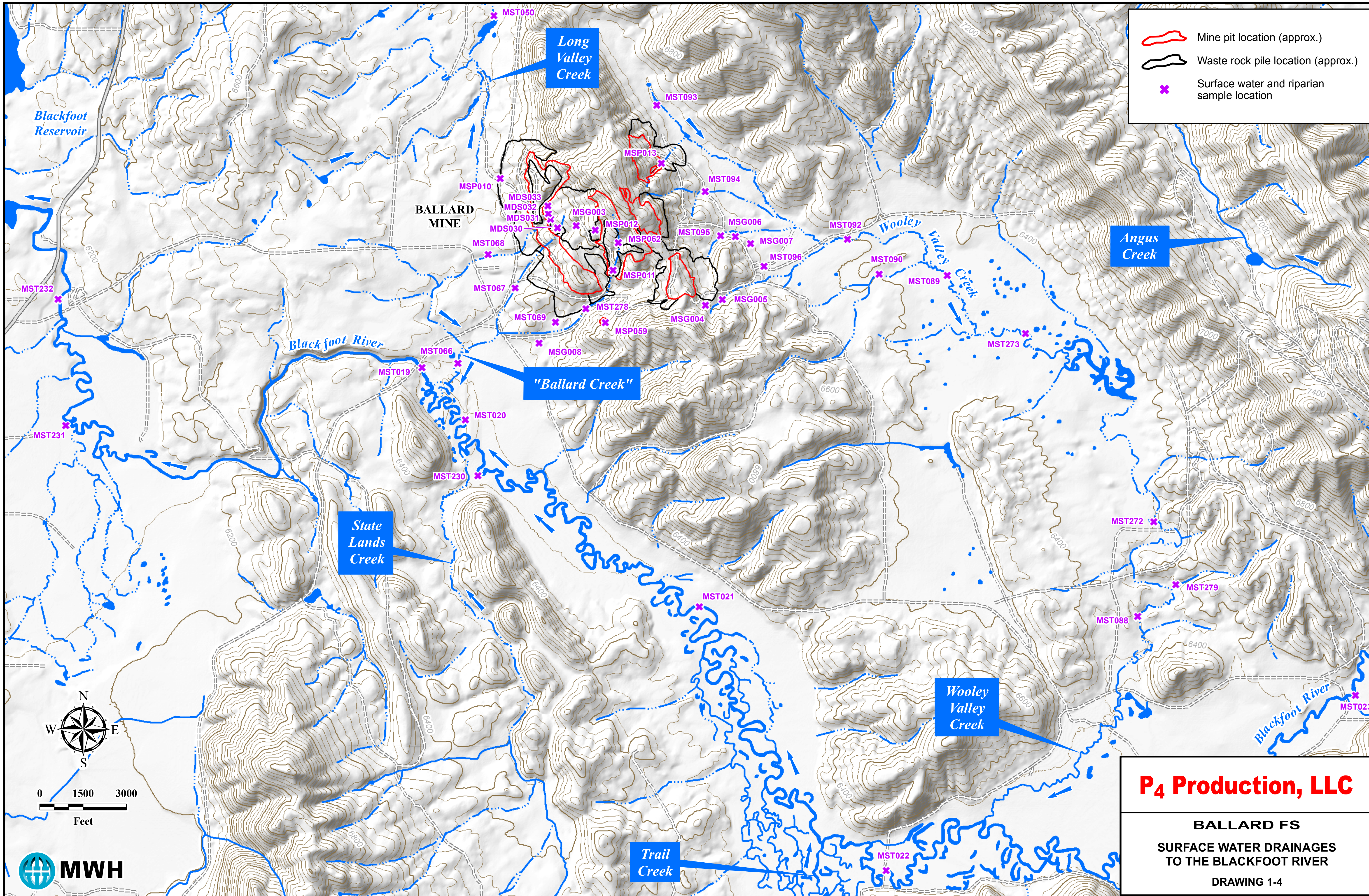
BALLARD MINE AREA DELINEATION MAP

Drawing 1-3

DRAWN BY C. Fowler

31 Jan 2015

D:\MWH\P4 Monsanto\P4_Ballard_FS_Jan2015\FIGURES\DWG 1-03_Ballard Mine Area Delineation Map_Jan2015.ai



DRAWN BY D. Severson

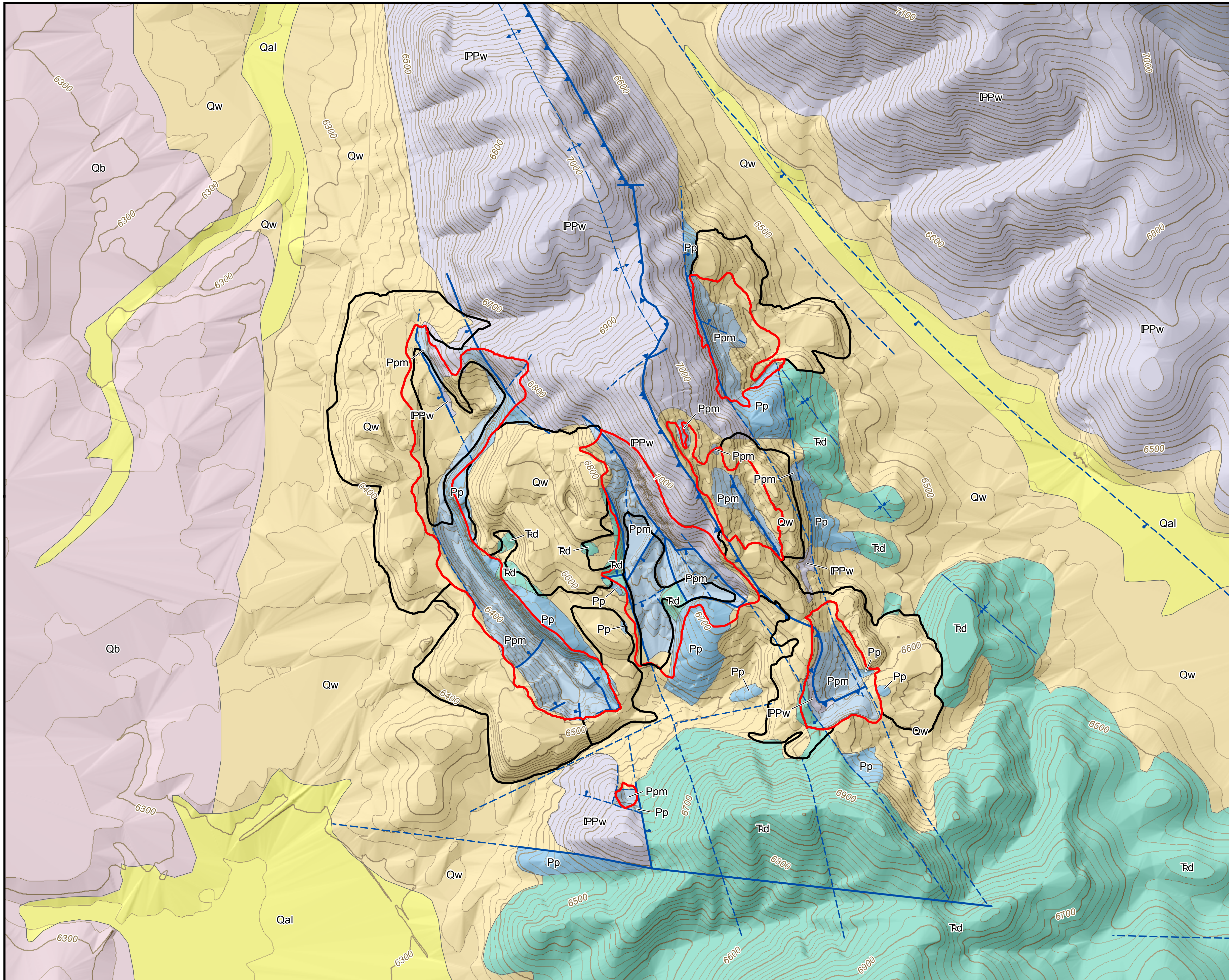
29 Jan 2015

D:\MWH\P4 Monsanto\P4_Ballard_FS_Jan2015\FIGURES\Dwg 1-04_Ballard_Surf Water Drain to Black River_hillshade_Jan2015.mxd

DRAWN BY D. Severson

30 Jan 2015

D:\MWH\P4 Monsanto\P4_Ballard_FS_Jan2015\FIGURES\Dwg 1-05_Ballard_Generalized Geologic Map_Jan2015.mxd



EXPLANATION

- Qb Basalt
- Qal Alluvium
- Qw Colluvium and older alluvium, may include areas covered in mine waste rock
- TRd Dinwoody Formation - Woodside Shale
- Pp / Ppm Phosphoria Formation Meade Peak Member
- PPw Wells Formation
- Mb Brazer Limestone

- Fault
- Approximate or inferred fault
- Normal fault (ball on downthrown block)
- Thrust fault
- Axis anticline
- Axis syncline

- Approximate mine pit location
- Approximate waste rock pile location

N E S W

0 600 1200

Feet

CONTOUR INTERVAL 20 FEET

GEOLOGIC DATA SOURCES: Hovland, 1981; Mansfield, 1927

P_4 Production, LLC

BALLARD FS

GENERALIZED GEOLOGIC MAP

Drawing 1-5

2 PRINCIPAL RI/BRA FINDINGS AND COCS/ROCS/COECS

This section summarizes the findings from the Ballard Mine RI and BRA as presented in the final *Ballard Mine RI Report,* and lists the preliminary and final COCs/ROCs/COECs for each medium based on review of the BRA and benchmarks for surface water and groundwater. Section 3.5 presents proposed Site-specific, risked-based preliminary cleanup levels for the COCs/ROCs/COECs identified in each medium.

2.1 NATURE AND EXTENT OF CONTAMINATION SUMMARY

As described in detail in Section 4.0 of the *Ballard Mine RI Report*, the nature and extent of constituents (i.e., COCs/ROCs/COECs) associated with the Ballard Site were identified through extensive sampling of the various media within and downslope of the Site and review of numerous investigations that confirmed characteristics of the mined materials and mining practices. The RI findings regarding all media provide sufficient information to characterize the nature and extent of contamination associated with vegetation on the Ballard Site (MWH, 2014). **Drawings 2-1** to **2-3** show the sampling and monitoring locations for the various media.

The primary known/recognized source of contaminants associated with phosphate mining in southeast Idaho is the Meade Peak Member of the Phosphoria Formation. In particular, the waste shale between ore horizons contributes much of the constituent loading. This is in part because the center waste shale, as it is known, represents a significant portion of the overburden rock that is stockpiled in waste rock dumps when the ore is removed, and is enriched with COCs/ROCs/COECs which includes metals, metalloids, naturally occurring uranium, and uranium-daughter products (e.g., radium-226 and radon-222). With few exceptions, constituents are leached from the waste rock in mine dumps through precipitation contact, which either directly runs off as surface water, mostly during the spring snowmelt, or infiltrates into the mine dump and appears as contaminated springs at the toe of the dumps. Water can continue downward through the mine waste rock dumps, infiltrate into the underlying shallow groundwater, and then appear as seeps in the stream channels leading from the Site or as shallow groundwater plumes leading from the source area..

In general, groundwater contamination in bedrock at the Site appears to be limited to the area immediately surrounding the mine pits. Sediments and surface water in the stream channels leading from the waste rock dumps and associated ponds contain some elevated constituents. However, the constituent concentrations rapidly decrease in the downstream direction and are most elevated in the on-Site pond locations. Similarly, riparian soils and riparian vegetation contain constituents, which are most elevated near the dumps and on-Site pond locations, but rapidly decrease in the downstream direction. Upland soils collected primarily from the soils overlying the waste rock dumps, and also along haul roads and other operational areas, are comprised in many cases of center waste shale that contain elevated constituents (as would be expected) as does the vegetation that grows upon the mine dumps. In summary, the areal distribution of constituents is limited to the waste rock in the mine dumps and pit backfill throughout the Site, and contamination is transported a relatively short distance downslope by a combination of surface water and groundwater that have elevated constituents because of precipitation contact with waste rock. Key findings of the nature and extent evaluation for the Ballard Site are presented by medium in the subsections below.

2.1.1 Upland Soil and Waste Rock

Concentrations of most constituents in the upland soil samples collected across waste rock dumps, mine pit backfill, and the haul road are elevated above screening and background levels for several metals/metalloids/radionuclides as discussed in Section 4.1 of the *Ballard RI Report* and the *On-Site and Background Areas Radiological Soil Investigation Summary Report* (*Background and Radiological Soils Report*; MWH, 2015a). Screening levels, as referenced in Section 2.0, are based on conservative promulgated standards as defined in Section 4.0 of the *Ballard RI Report*.

There is a wide range of constituent concentrations in these soil samples that reflects the heterogeneous nature of the waste rock deposited in the dumps and backfilled pits (see **Drawing 2-4)**. Soil sample results from transect sampling collected near the edge of one waste rock dump suggested that minor off-dump transport is occurring. However, based on the 2014 on-Site and background areas radiological and soil investigations, off-dump transport does not appear to be a concern.

2.1.2 Upland and Riparian Vegetation

Upland vegetation samples collected from the various dumps and backfilled mine pits are elevated above background and screening levels for several metals/metalloids, as discussed in Section 4.2 of the *Ballard RI Report*. Similar to upland soils, there is a large range in metal concentrations in upland vegetation reflecting the heterogeneous nature of the mine waste rock materials and plant uptake of these constituents in these areas. Vegetation samples collected from culturally significant vegetation generally show low to non-detectable concentrations of mercury, molybdenum and selenium with some seasonal variations in selenium and molybdenum concentrations. During the 2009 seasonal investigations, higher concentrations were reported in forb samples collected in the fall compared to the spring. In addition, the 2009 investigation attempted to identify the selenium uptake potential of each species. Certain plant species have the ability to accumulate selenium at concentrations higher than observed in the soil/overburden (i.e., hyperaccumulators). Two vegetation species, classified as selenium accumulators, were found at the Ballard Site. Milk vetch (*Astragalus sp.)* was observed and Scarlet Indian paintbrush was rarely observed (*Castilleja miniata*).

Riparian vegetation samples collected in upstream locations (ponds, seeps and some springs) have concentrations of metals/metalloids elevated above screening and background levels similar to upland vegetation. However, constituent concentrations in riparian vegetation decrease significantly downstream, as noted at the spring and stream stations.

2.1.3 Riparian Soils and Sediment

Concentrations of several constituents are elevated above screening and background levels in riparian soils and sediments samples collected from upstream locations and some downstream locations (streams) as discussed in Section 4.4 of the *Ballard RI Report*. The suite of constituents in riparian soils and sediments that exceed screening levels are similar to constituents found in upland soils and surface water. Constituent concentrations in riparian soils and sediments significantly decrease in downstream locations as shown for selenium on **Drawing 2-5**, but still are elevated in some sediments samples above screening and background levels for several constituents at the furthest monitored downstream locations (e.g., at MST272 and MST273 for antimony, selenium, uranium, and vanadium, which are located off of P4 property). However, concentrations of most constituents approach background values at the downstream locations.

2.1.4 Surface Water

Surface water samples collected from intermittent/ephemeral streams and perennial dump seeps, springs and ponds associated with the Ballard Site often contain elevated concentrations of metals/metalloids above their respective screening and background levels as discussed in Section 4.3 of the *Ballard RI Report*. Surface water samples collected from dump seeps, springs, and ponds located near the mine waste dumps contain a greater number of elevated constituents when compared to intermittent/ephemeral stream samples, which generally are collected downstream from these sources. In addition, several small tributaries that originate in the mine area also exceed background and screening levels for selenium and other constituents downstream of P4 property (refer to **Drawing 2-5**).

The Ballard Site is located in a headwater area with small, generally intermittent/ephemeral streams flowing towards larger drainages off-Site. Most of the headwater streams in the area only flow during snowmelt runoff. However, a few streams are fed by perennial springs that only flow for a short distance before infiltrating. These streams then typically are dry downstream of the infiltrating spring water. In general, the tributaries emanating from the Ballard Site do not contribute to contaminant loading during base or low flow conditions and the total runoff and storm water contribution to the Blackfoot River from the Site is minor.

2.1.5 Groundwater

Selenium is the most consistently elevated constituent that exceeds groundwater screening levels (see **Drawing 2-6**). Other constituents sporadically may exceed their screening levels (i.e., exceed levels in a single event at a single location, exceed in a very few locations [e.g., dump seeps], or exceed in total but not dissolved fractions) as discussed in Section 4.5 of the *Ballard RI Report*.

The local, intermediate, and regional aquifers associated with the Ballard Site have the following noted impacts from the sources of contamination (i.e., the waste rock dumps):

- Shallow alluvial groundwater on the east side of the mine is impacted by two waste rock dumps and this has resulted in three distinct plumes (**Drawing 2-7**) off of P4 property. On the west side of the mine, alluvial groundwater is impacted by two waste rock dumps and this has resulted in two distinct selenium plumes (**Drawing 2-8**) that have migrated off of P4 property.

- Groundwater collected from monitoring wells screened near the top of the Dinwoody Formation on the east side of the mine exceeds the selenium screening level; whereas, monitoring wells screened deeper in the Dinwoody Formation report selenium concentrations less than the screening level.

- Three of the five monitoring wells installed in the Wells Formation at the Ballard Site have total selenium concentrations in groundwater above the screening level and are located on the interior of the mine, but monitoring wells on the perimeter of the mine in the Wells Formation have selenium concentrations in groundwater below the selenium screening level.

2.2 CONTAMINANT FATE AND TRANSPORT SUMMARY

The transport of contaminants on and away from the Ballard Site is dominated by the movement in water, specifically surface water and shallow groundwater. Dispersion of mine-related constituents in the environment occurs as the result of dissolution of potential contaminants from center waste shales of the Phosphoria Formation, exposed in waste rock dumps or in mine pits, and the subsequent advection of dissolved constituents in surface water and groundwater. Of these, the surface water and associated sediment pathways are confined to relatively small stream channels that periodically flow to the much larger Blackfoot River. Shallow groundwater is as significant of a pathway as surface water, but much more complex and difficult to characterize. The remaining media, such as soil and vegetation, are relatively static and do not contribute significantly to the transport of contaminants. However, some dispersion occurs through soil erosion and downstream sediment and riparian soil may be related to the soil erosion pathway. There is not significant evidence that wind erosion has any major role at the Ballard Site.

There are three primary settings where center waste shale or other rocks associated with the Phosphoria Formation could be exposed to the environment and have the potential to leach constituents into groundwater.

- Locations where the center waste shale and other analyte-bearing rock have been placed in an external (outside the mine pit) waste rock dump (**Drawing 2-9**).
- Locations where the center waste shale and other analyte-bearing rock have been used to backfill a mine pit (**Drawing 2-10**).
- Locations where the center waste shale and other analyte-bearing rock are exposed in an open mine pit wall (**Drawing 2-11**).

There are some common components to the models that should be considered. This includes the observation that the P4 phosphate mines, including the Ballard Site in general, have been developed on mountainsides where the Phosphoria Formation is exposed at the surface. Typically, mining practices result in external waste rock being placed on the downhill side of the ore unit outcrop. This creates a condition where runoff and near-surface groundwater flow is directed in one direction – downslope away from the mine and can affect downgradient/downslope (i.e., off-Site) groundwater and surface water. However, there are exceptions at the Ballard Site where some waste rock dumps are uphill of a mine pit due to the complex area geology (i.e., repetition of the ore-bearing geologic section), which resulted in multiple adjacent pits. In this configuration, surface water and seep discharges from the waste rock are generally confined on-Site and include direct discharge to the downslope mine pits.

2.3 SUMMARY OF HUMAN HEALTH, ECOLOGICAL, AND LIVESTOCK RISKS DRIVERS BY MEDIUM

2.3.1 Human Health Risks

A human health risk assessment (HHRA) was performed using reasonable maximum exposure (RME) assumptions to evaluate risks of exposure to Site contaminants of potential concern (COPCs) for potential current and future human receptors. The current and/or future human receptors evaluated in the HHRA were: Native American, seasonal rancher, hypothetical future resident, recreational hunter, and recreational camper/hiker. **Table 2-1** summarizes human health risk estimates and preliminary COCs for each receptor by medium. Under hypothetical current/future land use conditions, certain human receptor scenarios are associated with incremental human health risk estimates greater than regulatory default risk standards – that is an incremental cancer risk of 1×10^{-5} (IDEQ) or 1×10^{-6} (USEPA) or an incremental hazard index (HI) greater than 1 and include Native American, hypothetical future resident, and seasonal rancher. The recreational hunter and camper/hiker receptors, which also were evaluated, fell below the risk thresholds listed above.

Constituents contributing most to incremental current/hypothetical future land use risk estimates above acceptable thresholds are:

- Antimony, arsenic, cadmium, molybdenum, selenium, thallium, and uranium in upland soil
- Arsenic, cadmium, molybdenum, nickel, selenium, thallium, and vanadium in riparian soil
- Arsenic, cadmium, and selenium in sediment
- Arsenic, selenium, and thallium in groundwater

Uranium daughter products were identified as preliminary ROCs for upland soil based on the results of health-protective, Tier I radiological risk evaluations presented in the *BRA* (MWH, 2014) and the *BRA Addendum* (MWH, 2015b). Tier I radiological cancer risk estimates for the hypothetical future resident, Native American, seasonal rancher, recreational hunter, and recreational camper/hiker were 2×10^{-1}, 1×10^{-2}, 5×10^{-4}, 2×10^{-4} and 1×10^{-4}, respectively, as shown in **Table 2-2**. The primary radiological risk drivers were radium-226 (all human receptors) and radon-222 (hypothetical future resident only), modeled from total uranium concentrations in upland soil. Tier I radiological cancer risk estimates for the above receptors, with the exception of the recreational camper/hiker, exceed both IDEQ and USEPA risk management criteria. The Tier I radiological cancer risk estimate for the recreational camper/hiker was above the IDEQ risk management criterion, but did not exceed the upper end of the USEPA acceptable risk management range equivalent to 1 x 10^{-4}. All of the radiological risk estimates presented above were based on sequential decay modeling of radium-226 activities from total uranium concentrations. In order to determine the actual concentrations of radium-226 in upland soil at the Site, a radiological site and background investigation was conducted in fall 2014 and results of this investigation are reported in the *Background and Radiological Soil Report*. The new radiological dataset will be used in radiological risk evaluations to be prepared for the Henry and Enoch Valley Sites.

For the Ballard Mine, Tier I radiological cancer risk estimates for the hypothetical future resident were reevaluated using measured radionuclide concentrations derived from the 2014 on-Site and background areas radiological investigation and compared to Tier I radiological cancer risk estimates presented in the *Ballard Mine BRA*. For this reevaluation, radiological cancer risk estimates for the hypothetical future resident were calculated using radium-226 concentrations predicted from the maximum gamma count results in upland soils at the Ballard Mine; and radon-222 indoor air concentrations modeled from the maximum radon flux measurements collected at the Ballard Mine. Tier I cancer risk estimates for a hypothetical future resident exposed to radionuclides in upland soils at the Ballard Mine using measured concentrations and concentrations based on secular equilibrium modeling are presented in **Table 2-3.** Radionuclide-specific and total cumulative Tier I cancer risk estimates for a hypothetical future resident exposed to measured concentrations of radionuclides in upland soils at the Ballard Mine are 8.0 x 10^{-3} (radium-226), 8.0 x 10^{-2} (radon-222), and 9 x 10^{-2} (total). Radionuclide-specific and total cumulative Tier I cancer risk estimates for a hypothetical future resident exposed to modeled concentrations of radionuclides in upland soils at the Ballard Mine, as reported in the BRA, are 2.9 x 10^{-3} (radium-226) 1.9 x 10^{-1} (radon-222), and 2 x 10^{-1} (total).

Based on the above comparison, the total Tier 1 cancer risk estimate for the hypothetical future resident exposed to radionuclides in upland soils at the Ballard Mine based on measured concentrations is only slightly lower than that based on modeled concentrations. The maximum measured on-Site concentrations of radium-226 and radon-222 are 82.4 picoCuries per gram (pCi/g) and 15,600 pCi per cubic meter (pCi/m3), respectively; while the concentrations of radium-226 and radon-222 modeled from total uranium concentrations detected on-Site were 29.2 pCi/g and 36,554 pCi/m3. As a result, the measured on-Site radium-226 concentration and corresponding Tier I cancer risk estimate are higher than values modeled from total uranium concentrations based on sequential decay modeling. In contrast, the measured on-Site radon-222 concentration and corresponding Tier I cancer risk estimate are lower than values modeled from total uranium concentrations.

Perhaps the most compelling findings from the 2014 on-Site and background areas radiological investigation are that the maximum radium-226 concentration measured in upland soils at the Ballard Mine (82.4 pCi/g) is only about three-fold higher than the maximum radium-226 concentration measured in background areas (27.2 pCi/g); while maximum radon-222 concentrations measured on-Site and in background areas are roughly equivalent (**Table 2-3**). As a result, the total cumulative radiological cancer risk estimates for the hypothetical future resident exposed to radionuclides in upland soils on-Site and in background areas are only marginally different (i.e., 9×10^{-2} vs. 7×10^{-2}).

It should be noted that grazing and recreational activities, such as hunting, camping and hiking, on the Ballard Mine, including leased State lands (i.e., the mine-disturbed area), are most representative of the current land uses possible on the Ballard Mine. Grazing and recreational activities also are the most likely future land uses for the Ballard Mine. As indicated by the *de minimis* cancer risk and non-cancer hazard estimates for the recreational hunter and camper/hiker receptors, these current and anticipated future land uses are not adversely affected at the Ballard Mine. The Native American, hypothetical future resident, and seasonal rancher were evaluated to determine if land use controls and/or RAs will be necessary to protect potential future subsistence, residential or seasonal ranching land uses for the Ballard Mine. Although land uses such as subsistence gathering and residential, which were assumed to occur exclusively on the Ballard Mine area in the HHRA, are unlikely to occur in the future.

Incremental cancer risk and non-cancer HI estimates for the Native American, hypothetical future resident, and seasonal rancher are greater than 1×10^{-4} and 1, respectively. Therefore, further evaluations in the FS of area-specific remedial alternatives, including institutional land use controls, will be required to protect these potential receptors/land uses on the Ballard Mine, proper. Because the concentrations of preliminary COCs/ROCs decrease rapidly in downslope directions from the mine dumps, it is not anticipated that current or potential future off-mine subsistence and residential or seasonal ranching land uses in the vicinity of the Ballard Mine are adversely impacted. However, as discussed in this memorandum, remedial options will be evaluated for both the mine-disturbed area footprint and potentially impacted lands in the vicinity of the mine (i.e., Ballard CERCLA Site boundary).

Ballard Shop Area. Site-related carcinogenic risks to hypothetical future residents from naphthalene in soil at the Ballard Shop fall within the USEPA risk management range, but the non-carcinogenic hazard criterion was exceeded by 1,2,4-trimethylbenzene in soil. Hydrocarbons associated with fuel were not detected in any significant concentrations. The concentrations of other organic compounds detected were well below screening levels. In addition, there were no site-related risks to hypothetical future residents from organics in groundwater. However, groundwater location (SB07) reported concentrations of tetrachloroethylene above the groundwater standard of 0.005 mg/l in 2011 and 2015. Given the current land ownership and continued industrial use of the Ballard Shop, future residential land use is unlikely. In addition, the stockpiled slag at the Ballard Shop, as noted in Section 1.4.2, ultimately will be addressed when the Shop area is no longer used. Any further potential action (additional monitoring or characterization) regarding organic constituents in soil and groundwater at the Ballard Shop will be addressed in the future.

A closure plan will be prepared as discussed in Section 1.3.1 for the Ballard Shop Area and submitted prior to finalization of FS Memo #2.

2.3.2 Ecological Risks

An ecological risk assessment (ERA) was performed using RME assumptions to bound risks for a select group of ecological receptors that include mammalian and avian species that are present and could be exposed to contaminants of potential ecological concern (COPECs) found in Site media. The ecological receptors evaluated in the ERA were: American goldfinch, American robin, coyote, deer mouse, elk, great blue heron, long-tailed vole, mallard, mink, raccoon and northern harrier. **Table 2-4** shows the range of Site-wide hazard quotients (HQs) for ecological receptors with HQs exceeding the EPA's and IDEQ's acceptable HQ of 1. Preliminary COECs contributing to HQ estimates above acceptable thresholds are:

- Antimony, cadmium, chromium, copper, molybdenum, nickel, selenium, thallium, vanadium and zinc in upland soil
- Antimony, cadmium, chromium, copper, molybdenum, nickel, selenium, thallium and vanadium in riparian soil
- Selenium in surface water
- Antimony, cadmium, copper, molybdenum, selenium, and thallium in sediment

In addition, the chemical-specific HQs for amphibians exposed to surface water potential COECs at the Ballard Site ranged from <1 to 101, with HQs calculated based on chronic aquatic life criteria that are protective of both acute and chronic effects.

Similar to human health risks, these ecological HQs represent upper bound estimates that tend to overestimate Site risks. For example, ecological HQ estimates calculated using background concentrations were greater than 1 for three of six mammalian receptors, and for two of five avian receptors, indicating that local wildlife are able to survive metals concentrations that are theoretically elevated, according to ecological risk assessment assumptions. Additionally, background ecological HQ estimates presented in the *Ballard Mine BRA* were based on the 2013 background dataset, and did not account for exposure to naturally elevated concentrations of COECs in the Phosphoria Formation. The 2014 background dataset includes higher concentrations of COECs compared to the 2013 background dataset. However, the ERA did not account for potentially higher selenium concentrations that may occur in hyperaccumulator plant species.

2.3.3 Livestock Risks

A livestock risk assessment (LRA) was performed to evaluate potential impacts of Site contaminants on grazing animals. The primary livestock species that currently, or historically, have grazed on reclaimed mine sites in the Phosphate Resource Area are beef cattle, sheep, and horses. However, these animals graze in the vicinity of the Ballard Mine, but not on the mine itself. Sheep, in particular, have a preference for forbs that may include selenium hyper-accumulator plant species, while beef cattle prefer grasses. As described in the BRA (MWH, 2014), sheep grazing on the P4 Mine Sites is not allowed under current Site management practices. However, the use of the land for the grazing of beef cattle is a desired beneficial use of reclaimed mine sites. Based on this information, beef cattle were selected as the livestock indicator receptor for evaluation in the LRA. Note that the LRA specifically did not account for potentially higher selenium concentrations that may occur in hyperaccumulator plant species. Based on factors listed in the uncertainty analysis for the HHERA (Section 6.8; MWH, 2014), uncertainty in risk results for livestock exposure models, which do not include potential analyte concentrations in selenium hyperaccumulators, is considered low.

Potential risks to beef cattle were evaluated following the methods and assumptions used to model exposures for large herbivorous ecological receptors. Beef cattle exposures were modeled for all livestock contaminants of potential concern (LCOPCs) identified in Ballard Mine surficial media. Tier II HQ estimates for beef cattle exposed to surficial media at the Site are shown in **Table 2-5** and ranged from 0.32 to 2.5. The only livestock contaminant of concern (LCOC) with a Tier II HQ > 1 for beef cattle was selenium in upland soil.

2.3.4 BRA Preliminary COC/ROCs/COECs/LCOCs

Based on the BRA findings discussed above, two tables were developed for the Ballard Site presenting preliminary contaminants of concern for human health (**Table 2-6**) and ecological risks (**Table 2-7)** for each medium. The preliminary COCs, ROCs, COECs, and LCOCs identified in these tables present the risk drivers for the various media with two exceptions. Following review of the BRA findings and the nature and extent of exceedances, thallium was identified in the HHRA as a preliminary COC in groundwater. However, only one of 19 groundwater samples that were analyzed for thallium exceeded the screening level of 0.00016 mg/L (USEPA RSL for tap water). The sample was collected from MMW020 in 2007 and was reported at 0.0011 mg/L. The MCL for thallium is 0.002 mg/L. As a result, thallium has not been included as a COC.

In addition, antimony was identified in the BRA as a preliminary COEC in riparian soil. However, based on further evaluation, antimony is eliminated as a preliminary COEC, as the sample concentrations are less than the background concentration in riparian soil.

2.4 SUMMARY OF BENCHMARKS FOR WATER

This section evaluates surface water and groundwater concentrations detected at the Ballard Site in relation to promulgated federal and state chemical-specific standards. The objective of this evaluation is to identify other constituents in surface water and groundwater that may not have been identified as risk drivers in the *Ballard BRA*, but may be considered COCs/COECs based on screening against benchmarks that have been developed and are recognized by the USEPA. The discussion of all chemical-specific ARARs is provided in Section 3.0 of this Ballard FS Memo #1; however, in summary, chemical-specific benchmarks are identified herein for surface water and groundwater only. The other primary media (i.e., upland soils, riparian soils, and sediment) do not have promulgated regulations regarding contamination that require cleanup (e.g., maximum contaminant limits or MCLs), they only have suggested regional screening levels for industrial and residential sites (refer to www.cleanuplevels.com)

The benchmarks for groundwater and surface water include the following sources of information:

- National Primary Drinking Water Regulations (MCLs) - 40 CFR Part 141
- National Recommended Water Quality Criteria (NRWQC) - Section 304(a) of CWA
- Idaho Water Quality Standards - IDAPA 58.01.02
- Idaho Groundwater Quality Rule - IDAPA 58.01.11.200

2.4.1 Surface Water

Analytes exceeding the benchmark criteria for surface water are listed in **Table 2-8** and include aluminum, arsenic, cadmium, copper, iron, manganese, nickel, and selenium. These exceedances were further evaluated to identify the nature and extent of these exceedances at the Ballard Site.

The Ballard RI found isolated instances of aluminum, copper, iron, and nickel exceeding surface water benchmarks in three springs (MSG006, MSG007, and MSG008), one surface water station (MST095), and two stock ponds (i.e., MSP011 and MSP059). The RI found multiple exceedances of arsenic, cadmium, manganese, and selenium in surface water downgradient of the Site.

The aluminum, iron, and manganese exceedances are attributed to high background concentrations. These constituents were detected in both surface water and groundwater and in several of the background surface water and groundwater locations. These analytes do not appear to be an indicator of mine impacts because there was no correlation between the detection of these metals in surface water and the detection of selenium. Furthermore, when both total and dissolved concentrations were detected, often the elevated concentrations were not present in the dissolved fraction indicating these constituents were present in the suspended fraction (e.g., turbidity) of the sample.

Based on the isolated occurrences of aluminum, copper, iron, and nickel exceedances and the elevated background concentrations of aluminum, iron, and manganese, these analytes are not identified as COCs/COECs in surface water. The surface water COCs/COECs then are limited to arsenic, cadmium, and selenium because Site-related concentrations exceed regulatory benchmarks and background levels at downstream locations at the Site.

2.4.2 Groundwater

Analytes that exceeded the primary MCLs in groundwater are listed in **Table 2-8** and include arsenic, cadmium, and selenium.

Sulfate and TDS are analytes that exceeded screening in the *Ballard RI Report,* but as they do not exceed enforceable standards they are not considered COCs during the selection of remediation technologies and alternatives for groundwater. However, they are relatively elevated in some locations on the Site, and they were used to help characterize the Site and need to be considered in technology selection as they can interfere (sulfate in particular) with some technological processes.

In addition, aluminum, iron, and manganese also exceeded screening or background levels as discussed in the *Ballard RI Report*. The detected aluminum, iron, and manganese levels appear to be within background concentrations in groundwater and do not appear to be indicators of mine impacts (i.e., no correlation to elevated selenium) As a result of this and the fact that these analytes do not exceed enforceable standards, aluminum, iron, and manganese are not considered COCs/COECs.

Because arsenic, cadmium, and selenium exceed enforceable benchmarks in multiple locations over several sampling events, and because the *Ballard BRA* identified arsenic and selenium as preliminary groundwater COCs (see **Table 2-5**), arsenic, cadmium, and selenium are considered COCs for groundwater.

2.5 COCs/ROCS/COECs BY MEDIUM FOR FS

The final list of COCs/ROCs/COECs for evaluation in the FS was developed based on the following criteria:

- Constituents (analytes) identified as risk drivers in the BRA – preliminary COCs/ROCs/COECs (Section 2.3 and **Tables 2-6** and **2-7**)

- Analytes that exceeded regulatory benchmarks – surface water and groundwater (Section 2.4 and **Table 2-8**)

Table 2-9 presents the final list of COC/ROCs/COECs in each Site medium. The COCs/ROCs/COECs identified on **Table 2-9** are used in the FS evaluations of each medium to determine the most viable technologies for remediation.

Table 2-1
Summary of Tier II RME Ballard Site Cumulative Risk Estimates for Human Receptors

	Current/Future Native American				Hypothetical Future Resident				Current/Future Seasonal Rancher				Current/Future Recreational Hunter & Current/Future Recreational Camper/Hiker			
	ILCR [a]	Risk Drivers [b]	HI [a]	Risk Drivers [b]	ILCR [a]	Risk Drivers [b]	HI [a]	Risk Drivers [b]	ILCR [a]	Risk Drivers [b]	HI [a]	Risk Drivers [b]	ILCR [a]	Risk Drivers [b]	HI [a]	Risk Drivers [b]
Upland Soil																
Site-Related	**4E-05**	As	1	--	**4E-05**	As	1	--	**1E-05**	As	0.6	--	<1E-06	--	< 1	--
Background	**1E-05**	As	0.2	--	**1E-05**	As	0.2	--	**3E-06**	As	0.08	--	<1E-06	--	< 1	--
Incremental	**3E-05**	As	1	--	**3E-05**	As	1	--	**8E-06**	As	0.5	--	<1E-06	--	< 1	--
Riparian Soil																
Site-Related	**1E-05**	As	0.9	--												
Background	**8E-06**	As	0.2	--												
Incremental	**3E-06**	As	0.7	--												
Culturally Significant Plant - Upland Soil[c]																
Site-Related	**2E-03**	As	**169**	As, Cd, Co, Mn, Sb, Se, Tl, U												
Background	**6E-03**	As	**135**	As, Cd, Co, Mn, Sb, Tl, U												
Incremental	--	--	**149**	Cd, Sb, Se, U												
Culturally Significant Plant - Riparian Soil[c]																
Site-Related	**5E-03**	As	**221**	As, Cd, Co, Mn, Mo, Ni, Sb, Se, Tl, V												
Background	**4E-03**	As	**142**	As, Co, Mn, Ni, Sb, Tl, V												
Incremental	**1E-03**	As	**93**	As, Cd, Mo, Ni, Se, Tl, V												
Aquatic Plant - Sediment[c]																
Site-Related	**6E-04**	As	**82**	As, Cd, Mn, Mo, Se, Zn												
Background	**2E-04**	As	**4**	Cd												
Incremental	**4E-04**	As	**77**	As, Cd, Se												
Fruits and Vegetables - Upland Soil and Groundwater[c,e,f]																
Site-Related					**2E-03**	As	**94**	As, Cd, Mo, Sb, Se, Tl								
Background					**6E-03**	As	**152**	As, Cd, Co, Mn, Mo, Ni, Sb, Se, Tl, V								
Incremental					--	--	**46**	Mo, Se, Tl								
Surface Water[d]																
Site-Related	**2E-06**	As	0.01	--												
Background	1E-07	--	0.0006	--												
Incremental	**2E-06**	As	0.009	--												

Table 2-1
Summary of Tier II RME Ballard Site Cumulative Risk Estimates for Human Receptors

	Current/Future Native American				Hypothetical Future Resident				Current/Future Seasonal Rancher				Current/Future Recreational Hunter & Current/Future Recreational Camper/Hiker			
	ILCR [a]	Risk Drivers [b]	HI [a]	Risk Drivers [b]	ILCR [a]	Risk Drivers [b]	HI [a]	Risk Drivers [b]	ILCR [a]	Risk Drivers [b]	HI [a]	Risk Drivers [b]	ILCR [a]	Risk Drivers [b]	HI [a]	Risk Drivers [b]
Groundwater[e]																
Site-Related					**3E-04**	As	**7**	As, Se, Tl	**6E-05**	As	**2**	--				
Background					**2E-05**	As	1	--	**4E-06**	As	0.01	--				
Incremental					**3E-04**	As	**6**	As, Se	**5E-05**	As	**2**	--				
Cattle - Upland Soil and Surface Water[d,g]																
Site-Related									**2E-04**	As	**44**	As, Co, Se, Tl				
Background									**5E-05**	As	**11**	Co, Tl				
Incremental									**1E-04**	As	**34**	Se, Tl				
Cattle - Upland Soil and Groundwater[e,g]																
Site-Related									**2E-04**	As	**44**	As, Co, Se, Tl				
Background									**5E-05**	As	**11**	Co, Tl				
Incremental									**1E-04**	As	**34**	Se, Tl				
Site-Related Cumulative Risk	**5E-03**		**223**		**3E-03**		**103**		**3E-04**		**46**		**7E-7/1E-6**		**0.03/0.04**	
Background Cumulative Risk	**6E-03**		**142**		**6E-03**		**153**		**6E-05**		**11**		**3E-7/4E-7**		**0.005/0.006**	
Incremental Cumulative Risk	**1E-03**		**150**		**3E-04**		**54**		**2E-04**		**36**		**4E-7/6E-7**		**0.03/0.03**	

Notes:

[a] Media-specific cumulative ILCR and HI for all COPCs following the Tier I risk assessment.

[b] Analytes with a chemical-specific Incremental Tier II RME ILCR or HQ greater than the USEPA's risk management range and/or IDEQ's acceptable risk criteria are listed as media-specific risk drivers.

[c] All media-specific COPCs were evaluated for the indirect pathways in addition to direct exposure pathways (i.e., ingestion, inhalation, and dermal contact) except sediment COPCs, which were evaluated through the indirect uptake to aquatic culturally significant plant pathway only. The indirect exposure route - ingestion of elk tissue - was not evaluated in the Tier II risk assessment due to the absence of excess Tier I risk or hazard.

[d] Dissolved concentration of metals in surface water was used in human health risk and hazard calculations for all analytes except for selenium, where the total surface water concentration was used.

[e] Total concentration of metals in groundwater was used in human health risk and hazard calculations for all analytes.

[f] The indirect exposure route - ingestion of fruits and vegetables grown in upland soil and irrigated with groundwater - was evaluated for all soil and groundwater COPCs. For an analyte that was a COPC in soil only, the measured non-culturally significant plant concentration, when available, was used to represent the fruits and vegetables concentration. If an analyte was a COPCs in groundwater, the fruits and vegetables exposure concentration was equal to the modeled concentration from groundwater plus either the measured non-culturally significant plant concentration when available, or the modeled concentration from soil. Fruit and vegetable COPCs from resulting from elevated measured metals concentrations plant tissue are indicated as COPCs in upland soil as well as in measured plants.

[g] The indirect exposure route - ingestion of cattle grazed on upland pasture - was evaluated with either surface or groundwater ingestion. Excess human health risk due to arsenic in cattle tissue resulted from both pasture and livestock drinking water.

Bold indicates exceedance of the USEPA's risk management range and/or IDEQ's acceptable risk criteria.
COPC - Chemical of Potential Concern
HI - Hazard Index
HQ - Hazard Quotient
IDEQ - Idaho Department of Environmental Quality
ILCR - Incremental lifetime cancer risk
RME - reasonable maximum exposure
USEPA - United States Environmental Protection Agency

Key:
As - arsenic
Cd - cadmium
Co - cobalt
Mn - manganese
Ni - nickel
Rn - radon
Se - selenium
Tl - thallium
U - uranium
V- vanadium
Zn - zinc

Table 2-2
Summary of Tier I Ballard Site Radiological Risk Estimates for Human Receptors

	Current/Future Native American		Hypothetical Future Resident		Current/Future Seasonal Rancher		Current/Future Recreational Hunter		Current/Future Recreational Camper/Hiker	
	ILCR [a]	Risk Drivers [b]	ILCR [a]	Risk Drivers [b]	ILCR [a]	Risk Drivers [b]	ILCR [a]	Risk Drivers [b]	ILCR [a]	Risk Drivers [b]
Upland Soil										
Site-Related	**1.2E-02**	Ra-226	**2.9E-03**	Ra-226	**5.4E-04**	Ra-226	**2.3E-04**	Ra-226	**1.4E-04**	Ra-226
Indoor Air										
Site-Related			**1.9E-01**	Rn-222						
Surface Water										
Site-Related	6.6E-07	--			**3.7E-06**	Ra-226	2.2E-07	--		
Site-Related Cumulative Risk	**1E-02**		**2E-01**		**5E-04**		**2E-04**		**1E-04**	

Notes:
[a] Media-specific cumulative ILCR for all ROCs.

[b] Analytes with a radionuclide-specific Incremental Tier I ILCR greater than the USEPA's risk management range and/or IDEQ's acceptable risk criteria are listed as media-specific risk drivers.

Bold indicates exceedance of the USEPA's risk management range and/or IDEQ's acceptable risk criteria.
IDEQ - Idaho Department of Environmental Quality
ILCR - Incremental lifetime cancer risk
USEPA - United States Environmental Protection Agency

Key:
Ra-226 - radium-226
Rn-222 - radon-222

Table 2-3
Tier I Ballard Site and Background Radiological Risk Calculation for a Hypothetical Future Resident
Based on Total Uranium Concentration, Measured Gamma Count/Predicted Radium-226 and Radon-222 Flux Data

	Ballard Mine		Background				Media-Specific Site Cancer Risk Estimate		Total Site Cancer Risk	Media-Specific Background Cancer Risk Estimate		Total Background Cancer Risk
Radionuclide	Soil EPC	Air EPC	Soil EPC	Air EPC	Total Soil PRG [c]	Indoor Air PRG [c]	Soil	Indoor Air		Soil	Indoor Air	
							ILCR		ILCR	ILCR		ILCR
Radiological Risks Based on Concentrations Modeled from Total Uranium [a]												
Uranium, Total (mg/kg)	87.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Uranium-238 (pCi/g)	29.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Radium-226 (pCi/g)	29.2	NA	NA	NA	1.0E-02	NA	**2.9E-03**	NA	**2.9E-03**	NC	NA	NC
Radon-222 (pCi/m^3)	NA	36,554	NA	NA	NA	1.95E-01	NA	**1.9E-01**	**1.9E-01**	NA	NC	NC
Cumulative ILCR:							**3E-03**	**2E-01**	**2E-01**	NC	NC	NC
Radiological Risks Based on Concentrations Derived in the On-Site and Background Areas Radiological and Soil Investigation Summary Report [b]												
Radium-226 (pCi/g)	82.4	NA	27.2	NA	1.0E-02	NA	**8.0E-03**	NA	**8.0E-03**	**2.7E-03**	NA	**2.7E-03**
Radon-222 (pCi/m^3)	NA	15,600	NA	12,700	NA	1.95E-01	NA	**8.0E-02**	**8.0E-02**	NA	**6.5E-02**	**6.5E-02**
Cumulative ILCR:							**8E-03**	**8E-02**	**9E-02**	**3E-03**	**7E-02**	**7E-02**
IDEQ Point-of-departure:									**10^{-5}**			**10^{-5}**
USEPA Risk Range:									**10^{-6} - 10^{-4}**			**10^{-6} - 10^{-4}**

Notes:

[a] The total uranium exposure point concentration (EPC) is based on the maximum detected concentration in Ballard Mine upland soil samples. Based on comments received during the development of the risk assessment work plan, measured total uranium concentrations were assumed to be representative of uranium-238 and radium-226 activity concentrations. As a result, the total uranium EPC (mg/kg) was converted to uranium-238 and radium-226 EPCs (pCi/g) with a conversion factor of 0.742/2.21 pCi/g/mg/kg. Approximately 1.25 pCi/L radon-222 is expected in indoor air when there is 1 pCi/g of radium-226 in soil. As a result, the radium-226 EPC (pCi/g) was converted to an indoor air radon-222 EPC (pCi/m^3) with a conversion factor of 1250 pCi/m^3 air per pCi/g soil.

[b] Maximum radium-226 soil concentration modeled from the maximum gamma count result at the Ballard Mine and in background areas, and a linear regression between colocated gamma count data and radium-226 measurements. Maximum radon-222 indoor air concentration modeled from the maximum radon flux measurement at the Ballard Mine and in background areas.

[c] Based on the residential Preliminary Remediation Goals (PRGs) for radium-226+D and radon-222+D calculated using the online PRG calculator for radionuclides.

Bold indicates ILCR estimates above USEPA's risk management range or IDEQ's point of departure

EPC - exposure point concentration
IDEQ - Idaho Department of Environmental Quality
ILCR - incremental lifetime cancer risk
NA - not applicable
NC - not calculated

Table 2-4
Ecological Risk Drivers for the Tier II Evaluation at Ballard Site and Background Locations

	Long-Tailed Vole	Elk	American Goldfinch	Deer Mouse	Raccoon	American Robin	Mallard	Mink	Coyote	Great Blue Heron	Northern Harrier
NOAEL-Based Ecological Ha ard Estimates											
Site - Related:											
Hazard Range	< 0.1 - 91	--	< 0.1 - 44	< 0.1 - 47	< 0.1 - 1.2	< 0.1 - 16	< 0.1 - 8.5	< 0.1 - 96	< 0.1 - 1.4	< 0.1 - 9.0	< 0.1 - 1.3
Risk Drivers [a]	Cr Mo Ni Sb Se Tl	--	Cr Mo Se V	Cd Cr Mo Ni Sb Se Tl	Se	Cd Cr Cu Ni Se V Zn	Se V	Cd Cr Cu Mo Ni Sb Se Tl U V Zn	Mo	Cd Se V	Se
Background:											
Hazard Range	< 0.1 - 2.6	--	< 0.1 - 2.0	< 0.1 - 4.3	< 0.1 - 0.17	< 0.1 - 1.3	< 0.1 - 0.12	< 0.1 - 25	< 0.1 - 0.24	< 0.1 - 0.39	< 0.1 - 0.21
Risk Drivers [a]	Mn Mo Se Tl	--	V	Cd Mo Ni Tl	--	Cd V	--	Cr Cu Ni Sb Se Tl	--	--	--
LOAEL-Based Ecological Ha ard Estimates											
Site - Related:											
Hazard Range	< 0.1 - 90	--	< 0.1 - 34	< 0.1 - 46	< 0.1 - 1.2	< 0.1 - 13	< 0.1 - 6.7	< 0.1 - 94	< 0.1 - 0.76	< 0.1 - 7.1	< 0.1 - 1.1
Risk Drivers [a]	Cr Mo Ni Se Tl	--	Cr Se V	Cd Cr Mo Ni Se Tl	Se	Cd Cr Ni Se V Zn	Se	Cd Cr Cu Mo Ni Sb Se Tl V Zn	--	Se V	Se
Background:											
Hazard Range	< 0.1 - 1.5	--	< 0.1 - 1.6	< 0.1 - 2.2	< 0.1 - 0.031	< 0.1 - 0.96	< 0.1 - 0.096	< 0.1 - 2.9	< 0.1 - 0.080	< 0.1 - 0.34	< 0.1 - 0.18
Risk Drivers [a]	Mn Se	--	--	Cd	--	--	--	Cr Cu Ni Sb Se Tl	--	--	--

Notes:
[a] Risk drivers are analytes for which an analyte-specific greater than the USEPA's and IDEQ's acceptable criterion of one was calculated.

-- - not applicable
IDEQ - Idaho Department of Environmental Quality
LOAEL - lowest observed adverse effects level
NOAEL - no observed adverse effects level
USEPA - United States Environmental Protection Agency

Cd - cadmium
Cr - chromium
Cu - copper
Mo - molybdenum
Ni - nickel

Sb - antimony
Se - selenium
Tl - thallium
U - uranium
V- vanadium
Zn - zinc

Table 2-5
Livestock Risk Drivers for the Tier I and Tier II Evaluations at Ballard Site and Background Locations

	Tier I NOAEL-Based	Tier II-NOAEL-Based	Tier II LOAEL-Based
Site - Related:			
Hazard Range	< 0.001 - 20	0.32 - **2.5**	0.32 - **2.5**
Risk Drivers [a]	Mo Se Tl	Se	Se
Background:			
Hazard Range	< 0.001 - 0.70	0.031 - 0.063	0.0031 - 0.036
Risk Drivers [a]	--	--	--

Notes:
[a] Risk drivers are analytes for which an analyte-specific greater than the USEPA's and IDEQ's acceptable criterion of one were calculated.

Bold indicates exceedance of the USEPA's risk management range and/or IDEQ's acceptable risk criteria.

-- - not applicable
IDEQ - Idaho Department of Environmental Quality
LOAEL - lowest observed adverse effects level
NOAEL - no observed adverse effects level
USEPA - United States Environmental Protection Agency

Mo - molybdenum
Se - selenium
Tl - thallium

Table 2-6
Summary of Preliminary Human Health Contaminants/Radionuclides of Concern based on the Ballard Site BRA

COC/ROC	Direct Exposure				Indirect Exposure										
					Culturally Significant Plants					Fruits and Vegetables			Cattle		
	Upland Soil	Riparian Soil	Surface Water[a]	Ground-water[b]	Upland Soil	Measured Upland Plant	Riparian Soil	Measured Riparian Plant	Sediment	Upland Soil	Ground-water	Measured Upland Plant	Upland Soil	Surface Water	Ground-water
Aluminum															
Antimony					X										
Arsenic	X	X	X	X			X		X				X	X	X
Barium															
Beryllium															
Boron															
Cadmium					X	X	X	X	X						
Chromium															
Cobalt															
Copper															
Fluoride															
Iron															
Lead															
Manganese															
Mercury															
Molybdenum							X	X		X		X			
Nickel							X								
Radium-226	X				X										
Radon-222	X														
Selenium				X	X	X	X	X	X	X	X	X	X		
Silver															
Thallium							X			X	X[c]	X	X		
Uranium	X				X[d]										
Vanadium							X								
Zinc															

Notes:
X - preliminary COC/ROC. Analytes with a chemical-specific incremental Tier II RME ILCR or HQ greater than USEPA's risk management range (ILCR>1E-06 and HQ>1) and/or IDEQ's acceptable risk criteria (1E-05 and HQ>1) for any human receptor are listed as a preliminary COC/ROC.

[a] Dissolved concentration of metals in surface water was used in human health risk and hazard calculations for all analytes except for selenium, where the total surface water concentration was used.

[b] Total concentration of metals in groundwater was used in human health risk and hazard calculations for all analytes.

[c] Not Considered a preliminary COC in the FS based on 1 event exceedance in one well (MMW20)

[d] Uranium is identified as a COC based on the modeled plant tissue concentration only, because uranium was not detected in culturally significant plant tissue samples. If the maximum detection limit is used, uranium is not a COC for culturally significant upland plants.

COC - contaminant of concern
NOAEL - no observed adverse effects level
IDEQ - Idaho Department of Environmental Quality
FS - Feasibility Study
BRA - Baseline Risk Assessment
HHRA - Human Health Risk Assessment
HQ - Hazard Quotient
ILCR - Incremental lifetime cancer risk
RME - reasonable maximum exposure
ROC - radionuclide of concern
USEPA - U. S. Environmental Protection Agency

Table 2-7
Summary of Preliminary Contaminants of Ecological Concern based on the Ballard Site BRA

COEC	Upland Soil	Riparian Soil	Surface Water [a]	Sediment
Aluminum				
Antimony	X	X[b]		X
Arsenic				
Barium				
Beryllium				
Boron				
Cadmium	X	X		X
Chromium	X	X		
Cobalt				
Copper	X	X		X
Fluoride				
Iron				
Lead				
Manganese				
Mercury				
Molybdenum	X	X		X
Nickel	X	X		
Selenium	X	X	X	X
Silver				
Thallium	X	X		X
Uranium				
Vanadium	X	X		X
Zinc	X			

Notes:

X - Preliminary COEC. Analytes with a chemical-specific Tier II NOAEL-based cumulative effects ecological hazard greater than USEPA's and IDEQ's acceptable hazard criterion of 1 for any ecological receptor are listed as a COEC.

[a] Dissolved concentration of metals in surface water was used in ecological hazard calculations for all analytes except for selenium, where the total surface water concentration was used.

[b] Not considered a COEC in FS based on background detections.

COEC - contaminant of ecological concern
FS - Feasibility Study
NOAEL - no observed adverse effects level
IDEQ - Idaho Department of Environmental Quality
USEPA - U. S. Environmental Protection Agency

Table 2-8
Summary of Surface Water and Groundwater Analytes Exceeding Benchmarks
Ballard Site

Analyte	Surface Water[a]	Standard	Groundwater[b]	Standard
Aluminum	X	NRWQC		
Antimony				
Arsenic	X	IDAPA 58.01.02	X	MCL
Barium				
Boron				
Cadmium	X	IDAPA 58.01.02	X	MCL
Chromium				
Cobalt				
Copper	X	IDAPA 58.01.02		
Iron	X	NRWQC		
Manganese	X	NRWQC		
Molybdenum				
Nickel	X	IDAPA 58.01.02		
Selenium	X	IDAPA 58.01.02	X	MCL
Sulfate				
Silver				
TDS				
Thallium				
Uranium				
Vanadium				
Zinc				

Notes:

X - analyte exceeds surface water/groundwater standard.

[a] Dissolved concentration of metals in surface water was used in the benchmark evaluation as specified in the standard for all analytes except for selenium, where the total surface water concentration was used as specified in the standard.

[b] Total concentration of metals in groundwater was used in benchmark evaluation for all analytes.

IDAPA 58.01.02 - State of Idaho Surface Water Quality for Aquatic Life (IDAPA 58.01.02); CCC or Water & Organisms (IDEQ, 2013)

MCL - USEPA primary Maximum Contaminant Level, National Drinking Water Regulations

NRWQC - National Recommended Water Quality Criteria (USEPA, 2013); Freshwater Standards for Chronic Criteria (CCC)

Table 2-9
Final Summary of Contaminants/Radionuclides of Concern and Contaminants of Ecological Concern
Ballard Site

COC/ROC/COEC	Upland Soil	Riparian Soil[a]	Sediment[a]	Surface Water	Groundwater
Aluminum					
Antimony	X[d]		X[b]		
Arsenic	X[c]	X[c]	X[c]	X[c]	X[c]
Barium					
Beryllium					
Boron					
Cadmium	X[d]	X[d]	X[d]	X[e]	X[e]
Chromium	X[b]	X[b]			
Cobalt					
Copper	X[b]	X[b]	X[b]		
Fluoride					
Iron					
Lead					
Manganese					
Mercury					
Molybdenum	X[d]	X[d]	X[b]		
Nickel	X[b]	X[d]			
Radium-226	X[c]				
Radon-222	X[c]				
Selenium	X[d]	X[d]	X[d]	X[b]	X[c]
Silver					
Sulfate					
TDS					
Thallium	X[d]	X[d]	X[b]		
Uranium	X[c]				
Vanadium	X[b]	X[d]	X[b]		
Zinc	X[b]				

Notes:
[a]As sediment and riparian soil are adjacent and contiguous throughout the Site, a combined sediment-riparian soil COC/COEC list is used during the evaluation of remedial technologies as discussed in Section 4.0.
[b] **X** - Identified as a COEC
[c] **X** - Identified as a COC/ROC
[d] **X** - Identified as a COC and COEC
[e] **X** - Identified as COC/COEC based on benchmarks

COC - contaminant of concern
COEC - contaminant of ecological concern
ROC - radionuclide of concern

DRAWN BY D. Severson

25 Jan 2015

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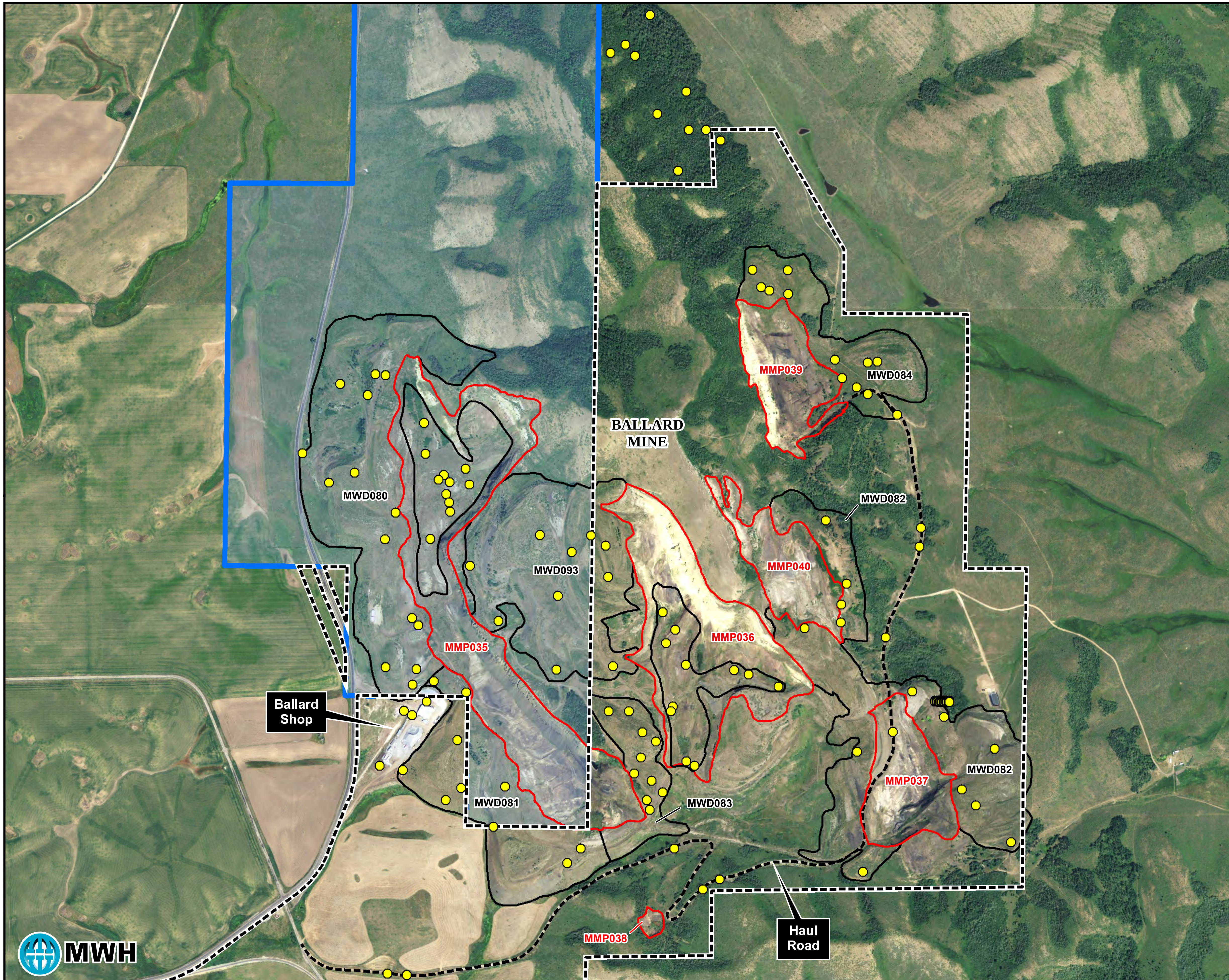


EXPLANATION

Approximate mine pit location (MMP)

Approximate waste rock pile location (MWD)

Surface soil and vegetation sample location

LAND OWNERSHIP

- P4 Property Boundary
- Other Private Land
- Bureau of Land Management
- U.S. Forest Service
- State

For specific soil and vegetation sample identification numbers and results refer to Ballard Mine RI Report.

N W E S

0 500 1000

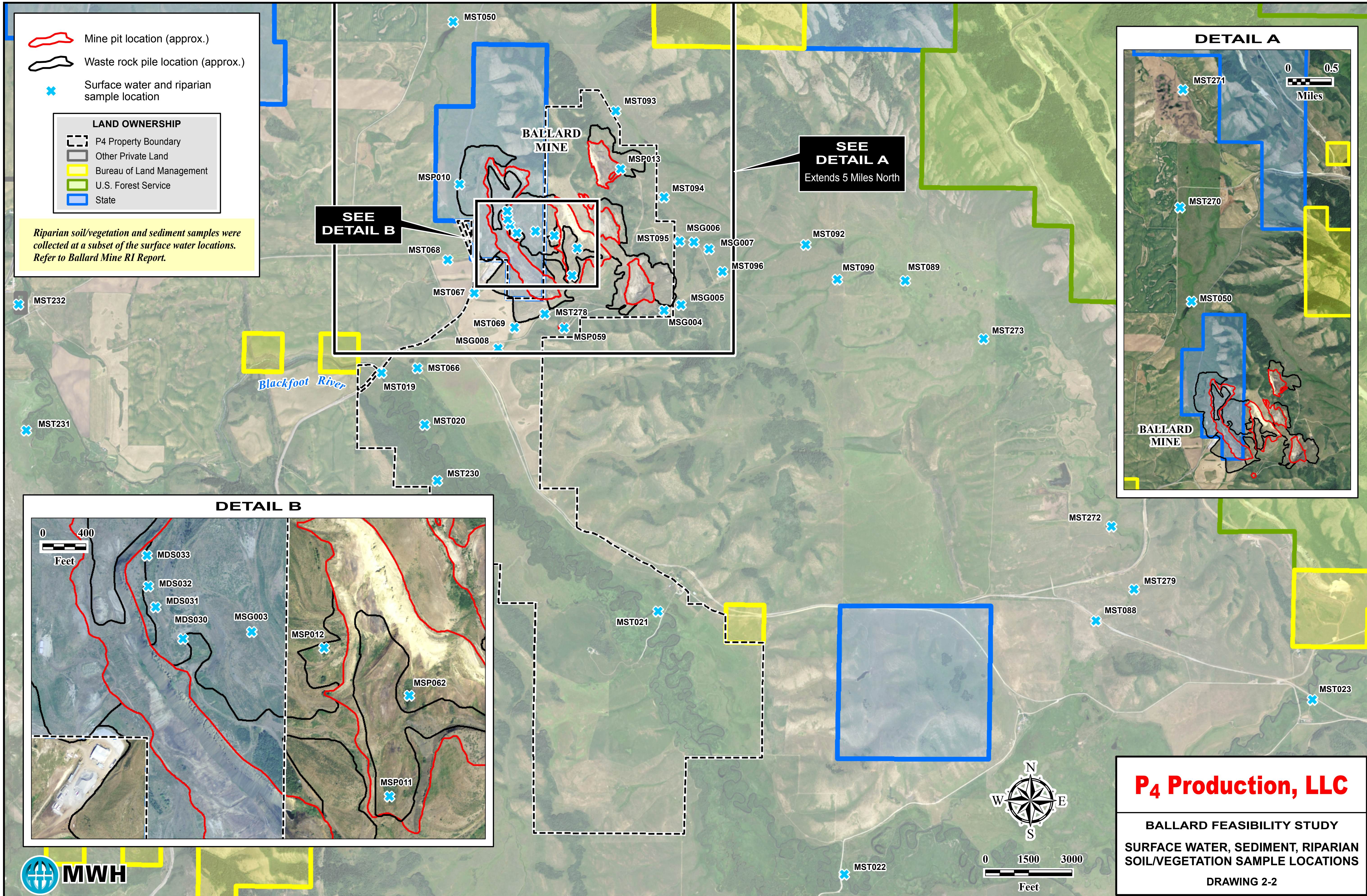
Feet

P$_4$ Production, LLC

BALLARD FS

UPLAND SOIL AND VEGETATION SAMPLE LOCATIONS

DRAWING 2-1



P4 Production, LLC

BALLARD FEASIBILITY STUDY

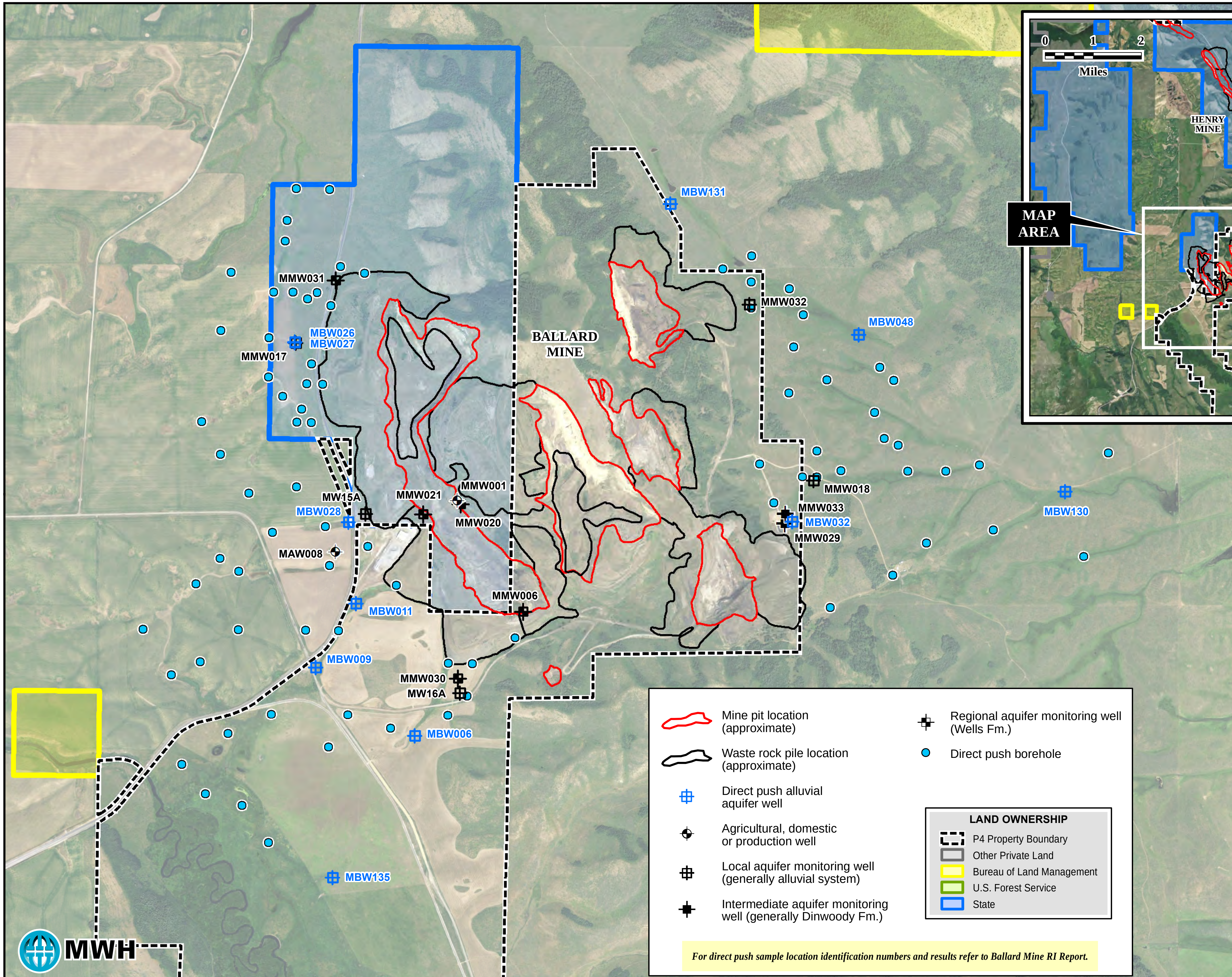
SURFACE WATER, SEDIMENT, RIPARIAN SOIL/VEGETATION SAMPLE LOCATIONS

DRAWING 2-2

DRAWN BY D. Severson

25 Feb 2016

C:\Data\MWH\P4 Monsanto\P4_Ballard_FS_Jan2015\FIGURES\Dwg 2-02_Surface Water and Riparian Sample Locs_Feb2016.mxd



P4 Production, LLC

BALLARD FS

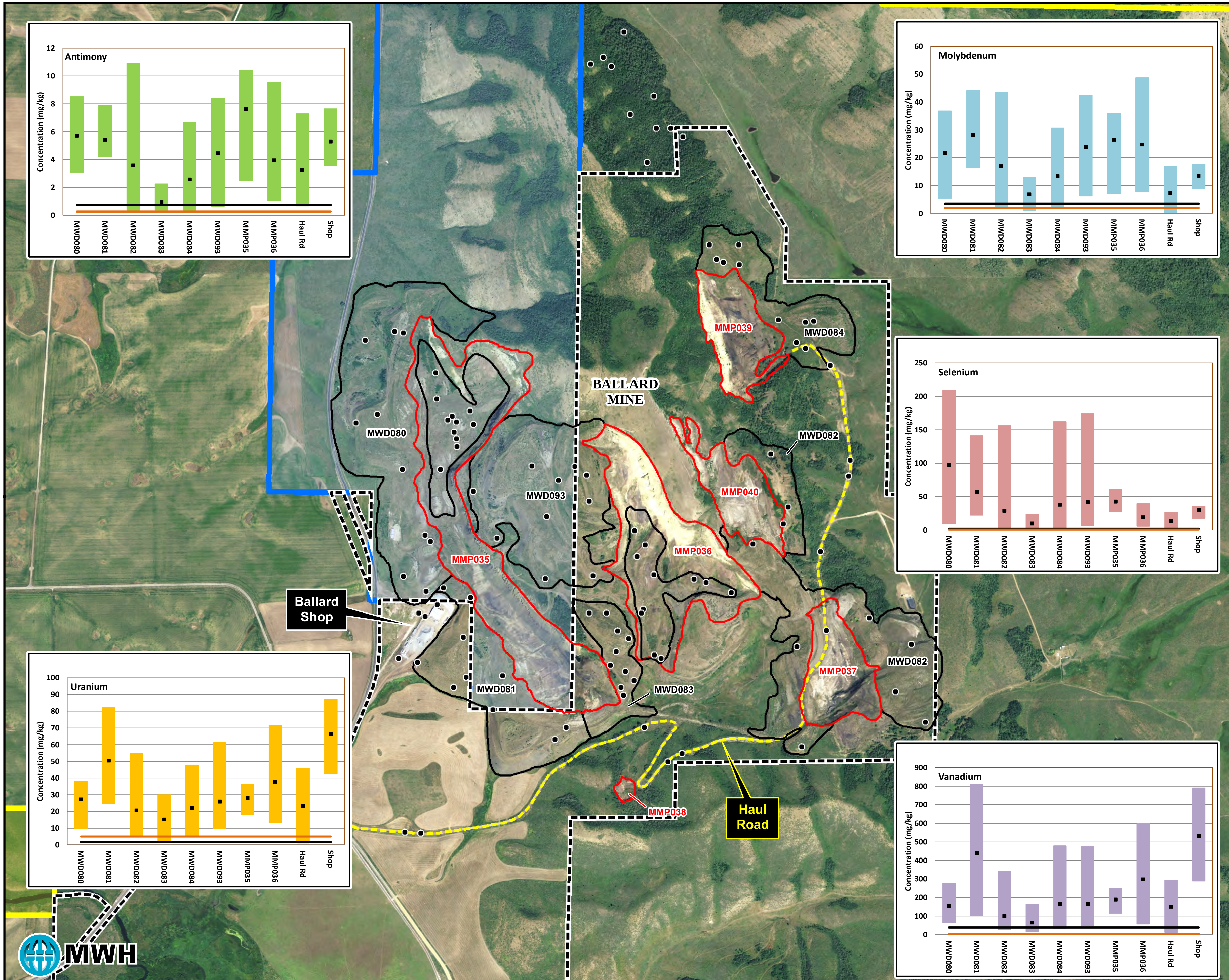
GROUNDWATER MONITORING LOCATIONS

DRAWING 2-3

DRAWN BY D. Severson

25 Jan 2015

D:\MWH\P4 Monsanto\P4_Ballard_FS_Jan2015\FIGURES\Dwg 2-03_Ballard_GW Monitoring Locations_Jan2015.mxd



EXPLANATION

Approximate mine pit location (MMP)

Approximate waste rock pile location (MWD)

Surface soil sample location

mg/kg Milligrams per kilogram

Maximum

Average

Minimum

Background

Screening level

LAND OWNERSHIP

P4 Property Boundary

Other Private Land

Bureau of Land Management

U.S. Forest Service

State

N W E S

0 600 1200

Feet

P$_4$ Production, LLC

BALLARD FS

UPLAND SOIL ANALYTE CONCENTRATION SUMMARY

DRAWING 2-4

DRAWN BY D. Severson

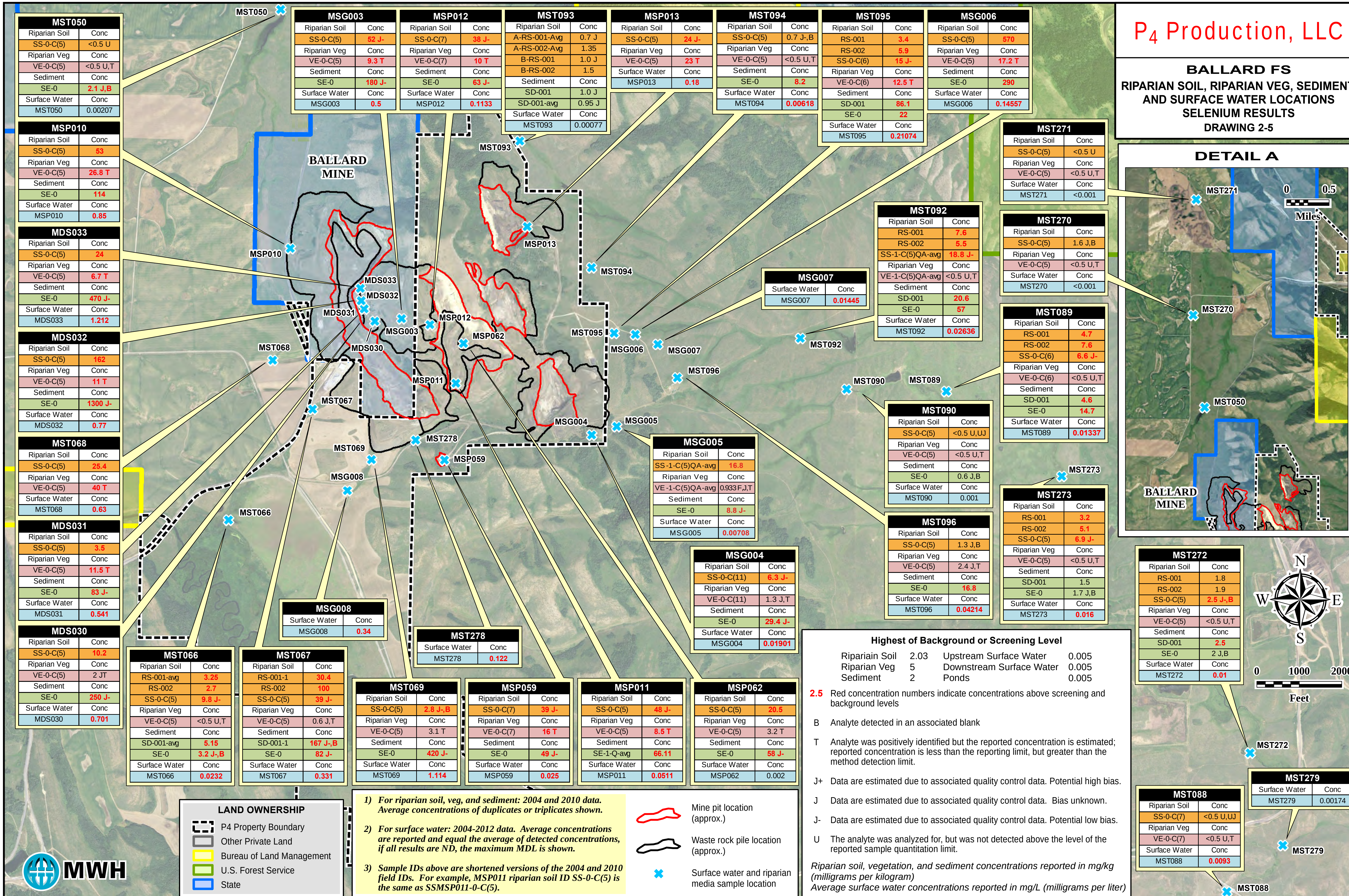
25 Jan 2015

D:\MWH\P4 Monsanto\P4_Ballard_FS_Jan2015\FIGURES\Dwg 2-04_Ballard_Upland Soil Analyte Conc Summary_Jan2015.mxd

DRAWN BY D. Severson
25 Jan 2015
D:\MWH\P4 Monsanto\P4_Ballard_FS_Jan2015\FIGURES\Dwg 2-05_Ballard_RipSoilVeg_Sed_SW_Selenium_Jan2015.mxd

P4 Production, LLC

BALLARD FS
RIPARIAN SOIL, RIPARIAN VEG, SEDIMENT, AND SURFACE WATER LOCATIONS SELENIUM RESULTS
DRAWING 2-5



MST050

Riparian Soil	Conc
SS-0-C(5)	<0.5 U
Riparian Veg	Conc
VE-0-C(5)	<0.5 U,T
Sediment	Conc
SE-0	2.1 J,B
Surface Water	Conc
MST050	0.00207

MSP010

Riparian Soil	Conc
SS-0-C(5)	53
Riparian Veg	Conc
VE-0-C(5)	26.8 T
Sediment	Conc
SE-0	114
Surface Water	Conc
MSP010	0.85

MDS033

Riparian Soil	Conc
SS-0-C(5)	24
Riparian Veg	Conc
VE-0-C(5)	6.7 T
Sediment	Conc
SE-0	470 J-
Surface Water	Conc
MDS033	1.212

MDS032

Riparian Soil	Conc
SS-0-C(5)	162
Riparian Veg	Conc
VE-0-C(5)	11 T
Sediment	Conc
SE-0	1300 J-
Surface Water	Conc
MDS032	0.77

MST068

Riparian Soil	Conc
SS-0-C(5)	25.4
Riparian Veg	Conc
VE-0-C(5)	40 T
Surface Water	Conc
MST068	0.63

MDS031

Riparian Soil	Conc
SS-0-C(5)	3.5
Riparian Veg	Conc
VE-0-C(5)	11.5 T
Sediment	Conc
SE-0	83 J-
Surface Water	Conc
MDS031	0.541

MDS030

Riparian Soil	Conc
SS-0-C(5)	10.2
Riparian Veg	Conc
VE-0-C(5)	2 JT
Sediment	Conc
SE-0	250 J-
Surface Water	Conc
MDS030	0.701

MSG003

Riparian Soil	Conc
SS-0-C(5)	52 J-
Riparian Veg	Conc
VE-0-C(5)	9.3 T
Sediment	Conc
SE-0	180 J-
Surface Water	Conc
MSG003	0.5

MSP012

Riparian Soil	Conc
SS-0-C(7)	38 J-
Riparian Veg	Conc
VE-0-C(7)	10 T
Sediment	Conc
SE-0	63 J-
Surface Water	Conc
MSP012	0.1133

MST093

Riparian Soil	Conc
A-RS-001-Avg	0.7 J
A-RS-002-Avg	1.35
B-RS-001	1.0 J
B-RS-002	1.5
Sediment	Conc
SD-001	1.0 J
SD-001-avg	0.95 J
Surface Water	Conc
MST093	0.00077

MSP013

Riparian Soil	Conc
SS-0-C(5)	24 J-
Riparian Veg	Conc
VE-0-C(5)	23 T
Surface Water	Conc
MSP013	0.18

MST094

Riparian Soil	Conc
SS-0-C(5)	0.7 J-,B
Riparian Veg	Conc
VE-0-C(5)	<0.5 U,T
Sediment	Conc
SE-0	8.2
Surface Water	Conc
MST094	0.00618

MST095

Riparian Soil	Conc
RS-001	3.4
RS-002	5.9
SS-0-C(6)	15 J-
Riparian Veg	Conc
VE-0-C(6)	12.5 T
Sediment	Conc
SD-001	86.1
SE-0	22
Surface Water	Conc
MST095	0.21074

MSG006

Riparian Soil	Conc
SS-0-C(5)	570
Riparian Veg	Conc
VE-0-C(5)	17.2 T
Sediment	Conc
SE-0	290
Surface Water	Conc
MSG006	0.14557

MST271

Riparian Soil	Conc
SS-0-C(5)	<0.5 U
Riparian Veg	Conc
VE-0-C(5)	<0.5 U,T
Surface Water	Conc
MST271	<0.001

MST092

Riparian Soil	Conc
RS-001	7.6
RS-002	5.5
SS-1-C(5)QA-avg	18.8 J-
Riparian Veg	Conc
VE-1-C(5)QA-avg	<0.5 U,T
Sediment	Conc
SD-001	20.6
SE-0	57
Surface Water	Conc
MST092	0.02636

MST270

Riparian Soil	Conc
SS-0-C(5)	1.6 J,B
Riparian Veg	Conc
VE-0-C(5)	<0.5 U,T
Surface Water	Conc
MST270	<0.001

MSG007

Surface Water	Conc
MSG007	0.01445

MST089

Riparian Soil	Conc
RS-001	4.7
RS-002	7.6
SS-0-C(6)	6.6 J-
Riparian Veg	Conc
VE-0-C(6)	<0.5 U,T
Sediment	Conc
SD-001	4.6
SE-0	14.7
Surface Water	Conc
MST089	0.01337

MST090

Riparian Soil	Conc
SS-0-C(5)	<0.5 U,UJ
Riparian Veg	Conc
VE-0-C(5)	<0.5 U,T
Sediment	Conc
SE-0	0.6 J,B
Surface Water	Conc
MST090	0.001

MSG005

Riparian Soil	Conc
SS-1-C(5)QA-avg	16.8
Riparian Veg	Conc
VE-1-C(5)QA-avg	0.933 F,J,T
Sediment	Conc
SE-0	8.8 J-
Surface Water	Conc
MSG005	0.00708

MST096

Riparian Soil	Conc
SS-0-C(5)	1.3 J,B
Riparian Veg	Conc
VE-0-C(5)	2.4 J,T
Sediment	Conc
SE-0	16.8
Surface Water	Conc
MST096	0.04214

MST273

Riparian Soil	Conc
RS-001	3.2
RS-002	5.1
SS-0-C(5)	6.9 J-
Riparian Veg	Conc
VE-0-C(5)	<0.5 U,T
Sediment	Conc
SD-001	1.5
SE-0	1.7 J,B
Surface Water	Conc
MST273	0.016

MSG004

Riparian Soil	Conc
SS-0-C(11)	6.3 J-
Riparian Veg	Conc
VE-0-C(11)	1.3 J,T
Sediment	Conc
SE-0	29.4 J-
Surface Water	Conc
MSG004	0.01901

MST272

Riparian Soil	Conc
RS-001	1.8
RS-002	1.9
SS-0-C(5)	2.5 J-,B
Riparian Veg	Conc
VE-0-C(5)	<0.5 U,T
Sediment	Conc
SD-001	2.5
SE-0	2 J,B
Surface Water	Conc
MST272	0.01

MSG008

Surface Water	Conc
MSG008	0.34

MST278

Surface Water	Conc
MST278	0.122

MST066

Riparian Soil	Conc
RS-001-avg	3.25
RS-002	2.7
SS-0-C(5)	9.8 J-
Riparian Veg	Conc
VE-0-C(5)	<0.5 U,T
Sediment	Conc
SD-001-avg	5.15
SE-0	3.2 J-,B
Surface Water	Conc
MST066	0.0232

MST067

Riparian Soil	Conc
RS-001-1	30.4
RS-002	100
SS-0-C(5)	39 J-
Riparian Veg	Conc
VE-0-C(5)	0.6 J,T
Sediment	Conc
SD-001-1	167 J-,B
SE-0	82 J-
Surface Water	Conc
MST067	0.331

MST069

Riparian Soil	Conc
SS-0-C(5)	2.8 J-,B
Riparian Veg	Conc
VE-0-C(5)	3.1 T
Sediment	Conc
SE-0	420 J-
Surface Water	Conc
MST069	1.114

MSP059

Riparian Soil	Conc
SS-0-C(7)	39 J-
Riparian Veg	Conc
VE-0-C(7)	16 T
Sediment	Conc
SE-0	49 J-
Surface Water	Conc
MSP059	0.025

MSP011

Riparian Soil	Conc
SS-0-C(5)	48 J-
Riparian Veg	Conc
VE-0-C(5)	8.5 T
Sediment	Conc
SE-1-Q-avg	66.11
Surface Water	Conc
MSP011	0.0511

MSP062

Riparian Soil	Conc
SS-0-C(5)	20.5
Riparian Veg	Conc
VE-0-C(5)	3.2 T
Sediment	Conc
SE-0	58 J-
Surface Water	Conc
MSP062	0.002

MST279

Surface Water	Conc
MST279	0.00174

MST088

Riparian Soil	Conc
SS-0-C(7)	<0.5 U,UJ
Riparian Veg	Conc
VE-0-C(7)	<0.5 U,T
Surface Water	Conc
MST088	0.0093

Highest of Background or Screening Level

Riparaian Soil	2.03	Upstream Surface Water	0.005
Riparian Veg	5	Downstream Surface Water	0.005
Sediment	2	Ponds	0.005

- 2.5 Red concentration numbers indicate concentrations above screening and background levels
- B Analyte detected in an associated blank
- T Analyte was positively identified but the reported concentration is estimated; reported concentration is less than the reporting limit, but greater than the method detection limit.
- J+ Data are estimated due to associated quality control data. Potential high bias.
- J Data are estimated due to associated quality control data. Bias unknown.
- J- Data are estimated due to associated quality control data. Potential low bias.
- U The analyte was analyzed for, but was not detected above the level of the reported sample quantitation limit.

Riparian soil, vegetation, and sediment concentrations reported in mg/kg (milligrams per kilogram)
Average surface water concentrations reported in mg/L (milligrams per liter)

1) *For riparian soil, veg, and sediment: 2004 and 2010 data. Average concentrations of duplicates or triplicates shown.*

2) *For surface water: 2004-2012 data. Average concentrations are reported and equal the average of detected concentrations, if all results are ND, the maximum MDL is shown.*

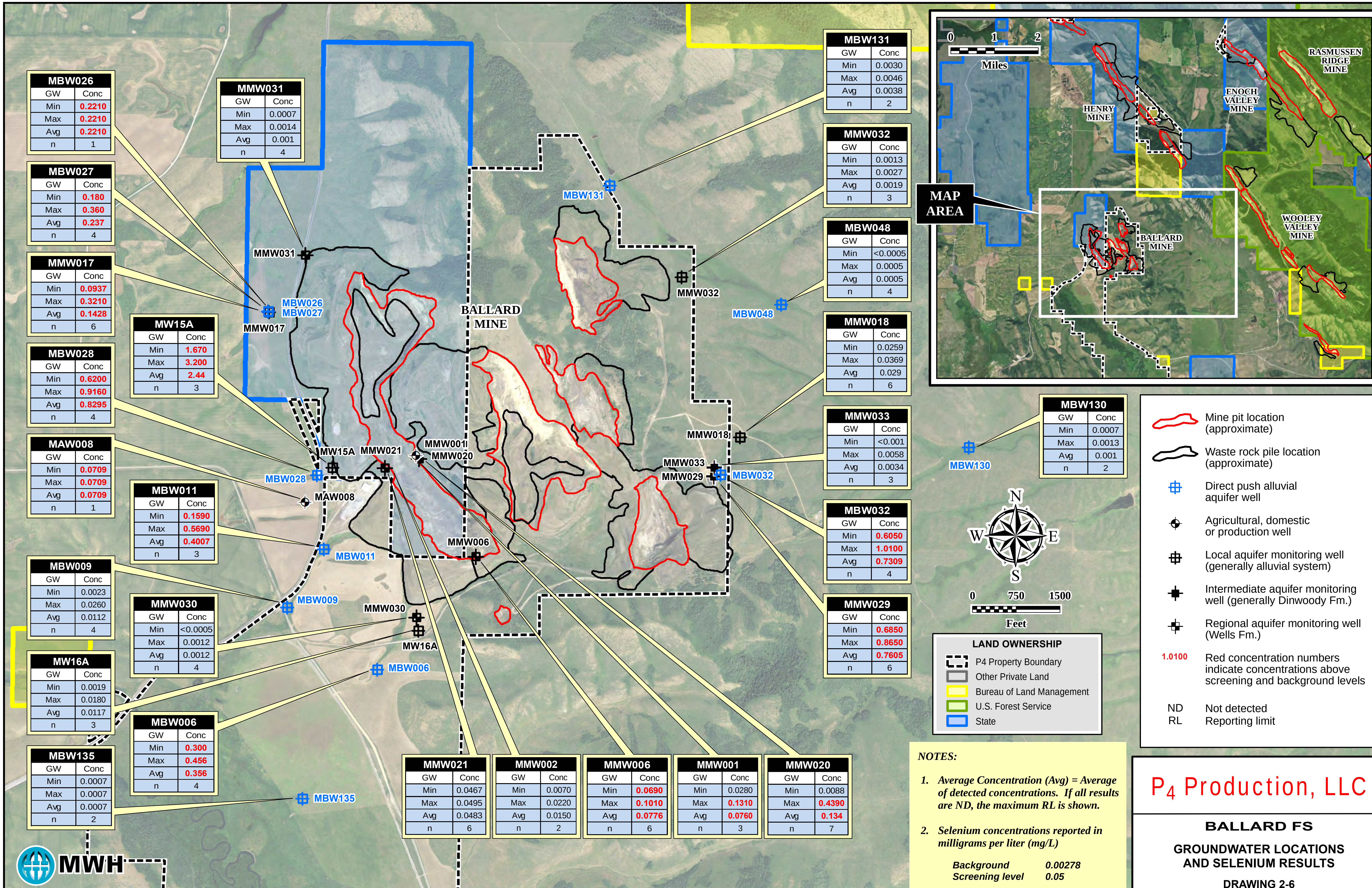
3) *Sample IDs above are shortened versions of the 2004 and 2010 field IDs. For example, MSP011 riparian soil ID SS-0-C(5) is the same as SSMSP011-0-C(5).*

- Mine pit location (approx.)
- Waste rock pile location (approx.)
- Surface water and riparian media sample location

LAND OWNERSHIP

- P4 Property Boundary
- Other Private Land
- Bureau of Land Management
- U.S. Forest Service
- State

MWH



MBW026	
GW	Conc
Min	0.2210
Max	0.2210
Avg	0.2210
n	1

MBW027	
GW	Conc
Min	0.180
Max	0.360
Avg	0.237
n	4

MMW017	
GW	Conc
Min	0.0937
Max	0.3210
Avg	0.1428
n	6

MBW028	
GW	Conc
Min	0.6200
Max	0.9160
Avg	0.8295
n	4

MAW008	
GW	Conc
Min	0.0709
Max	0.0709
Avg	0.0709
n	1

MBW009	
GW	Conc
Min	0.0023
Max	0.0260
Avg	0.0112
n	4

MW16A	
GW	Conc
Min	0.0019
Max	0.0180
Avg	0.0117
n	3

MBW135	
GW	Conc
Min	0.0007
Max	0.0007
Avg	0.0007
n	2

MMW031	
GW	Conc
Min	0.0007
Max	0.0014
Avg	0.001
n	4

MW15A	
GW	Conc
Min	1.670
Max	3.200
Avg	2.44
n	3

MBW011	
GW	Conc
Min	0.1590
Max	0.5690
Avg	0.4007
n	3

MMW030	
GW	Conc
Min	<0.0005
Max	0.0012
Avg	0.0012
n	4

MBW006	
GW	Conc
Min	0.300
Max	0.456
Avg	0.356
n	4

MMW021	
GW	Conc
Min	0.0467
Max	0.0495
Avg	0.0483
n	6

MMW002	
GW	Conc
Min	0.0070
Max	0.0220
Avg	0.0150
n	2

MMW006	
GW	Conc
Min	0.0690
Max	0.1010
Avg	0.0776
n	6

MMW001	
GW	Conc
Min	0.0280
Max	0.1310
Avg	0.0760
n	3

MMW020	
GW	Conc
Min	0.0088
Max	0.4390
Avg	0.134
n	7

MBW131	
GW	Conc
Min	0.0030
Max	0.0046
Avg	0.0038
n	2

MMW032	
GW	Conc
Min	0.0013
Max	0.0027
Avg	0.0019
n	3

MBW048	
GW	Conc
Min	<0.0005
Max	0.0005
Avg	0.0005
n	4

MMW018	
GW	Conc
Min	0.0259
Max	0.0369
Avg	0.029
n	6

MMW033	
GW	Conc
Min	<0.001
Max	0.0058
Avg	0.0034
n	3

MBW032	
GW	Conc
Min	0.6050
Max	1.0100
Avg	0.7309
n	4

MMW029	
GW	Conc
Min	0.6850
Max	0.8650
Avg	0.7605
n	6

MBW130	
GW	Conc
Min	0.0007
Max	0.0013
Avg	0.001
n	2

LAND OWNERSHIP
- P4 Property Boundary
- Other Private Land
- Bureau of Land Management
- U.S. Forest Service
- State

Mine pit location (approximate)
Waste rock pile location (approximate)
Direct push alluvial aquifer well
Agricultural, domestic or production well
Local aquifer monitoring well (generally alluvial system)
Intermediate aquifer monitoring well (generally Dinwoody Fm.)
Regional aquifer monitoring well (Wells Fm.)
1.0100 Red concentration numbers indicate concentrations above screening and background levels
ND Not detected
RL Reporting limit

NOTES:

1. *Average Concentration (Avg) = Average of detected concentrations. If all results are ND, the maximum RL is shown.*
2. *Selenium concentrations reported in milligrams per liter (mg/L)*

Background	*0.00278*
Screening level	*0.05*

P4 Production, LLC

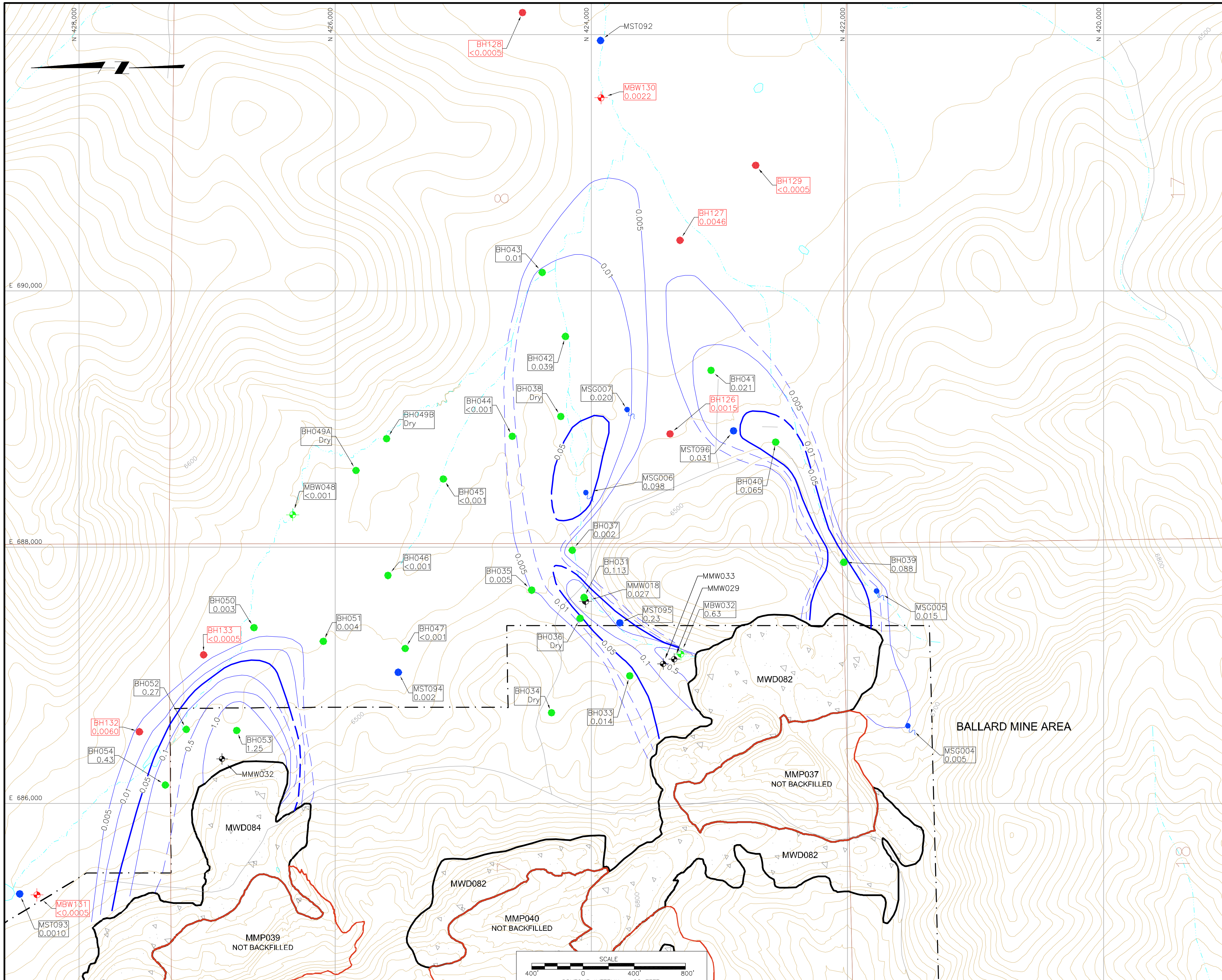
BALLARD FS

GROUNDWATER LOCATIONS AND SELENIUM RESULTS

DRAWING 2-6

MWH

DRAWING BY D. Severson
25 Jan 2015
D:\MWH\P4 Monsanto\P4_Ballard_FS_Jan2015\FIGURES\Dwg 2-06_Ballard_Groundwater Locs_Selenium_Jan2015.mxd



LEGEND:

- POST–MINE CONTOUR & ELEVATION, FEET
- POND OR LAKE
- STREAM – PERENNIAL
- STREAM – INTERMITTENT
- MINE PIT LOCATION (APPROXIMATE WHERE COVERED BY BACKFILL)
- WASTE ROCK DUMP LOCATION (APPROXIMATE)
- WASTE ROCK DUMP LOCATION OR PIT BACKFILL (APPROXIMATE)
- HIGHWAY
- ROAD
- RAILROAD
- P4 PRODUCTION HAUL ROAD (ACTIVE & INACTIVE)
- 0.05 TOTAL SELENIUM ISOCONCENTRATION CONTOUR (mg/L)
- 0.05 INFERRED TOTAL SELENIUM ISOCONCENTRATION CONTOUR (mg/L)
- P4 PRODUCTION PROPERTY BOUNDARY (APPROXIMATE)
- SECTION LINES
- 8 SECTION NUMBER
- BLM LANDS
- STATE LANDS
- OTHER PRIVATE LANDS

STATION TYPE:

- MSG = SPRING STATION
- MST = STREAM STATION
- MMW = GROUND WATER MONITORING WELL
- MBW = DIRECT PUSH MONITORING WELL INSTALLED IN 2008
- MBW = DIRECT PUSH MONITORING WELL INSTALLED IN 2009
- BH = 2008 DIRECT PUSH BOREHOLE
- BH = 2009 DIRECT PUSH BOREHOLE

KEY:

MMP = MINE PIT
MWD = WASTE ROCK DUMP

BH043 0.01 — 2008 DIRECT PUSH BOREHOLE ID AND DISSOLVED SELENIUM CONCENTRATION

BH043 0.01 — 2009 DIRECT PUSH BOREHOLE ID AND DISSOLVED SELENIUM CONCENTRATION

<0.001 CONCENTRATION LESS THAN THE METHOD DETECTION LIMIT

NOTES:

1. WHERE WELLS ARE NESTED IN THE ALLUVIAL FLOW SYSTEM (I.E. SHALLOW AND DEEPER) THE HIGHEST MEASURED CONCENTRATION IS USED FOR CONTOURING.
2. SPRING 2008 TOTAL SELENIUM CONCENTRATIONS ARE USED FOR MONITORING WELLS, SPRINGS AND HEADWATER STREAMS WHERE APPROPRIATE.
3. ISOCONCENTRATION CONTOUR INTERVAL=LOG WITH SUPPLEMENTAL HALF CYCLE CONTOURS.
4. BEDROCK WELLS ARE SHOWN FOR REFERENCE. SELENIUM CONCENTRATIONS ARE NOT SHOWN FOR THESE WELLS.

ISSUE	DESCRIPTION	CHF	CLF	
0	ISSUED DRAFT FOR CLIENT REVIEW	CHF	CLF	
REV	DESCRIPTION	TECH	ENG	DATE

DISCLAIMER:
THIS DRAWING WAS DEVELOPED THROUGH THE APPLICATION OF PROFESSIONAL ENGINEERING SKILL AND PROPRIETARY METHODOLOGIES, PROCESSES AND KNOW HOW OF MWH AS AUTHOR ALL PURSUANT TO THE TERMS OF A CONTRACTUAL SCOPE OF WORK GOVERNING ITS PREPARATION. THIS DRAWING MAY NOT BE USED OR MODIFIED OTHER THAN IN STRICT ACCORDANCE WITH THE TERMS OF THE GOVERNING CONTRACT AND SCOPE OF WORK OR OTHERWISE ABSENT THE INVOLVEMENT AND CONSENT OF THE AUTHOR. ANY ALTERATION OR ADAPTATION OF THIS DRAWING SHALL BE CONSISTENT WITH THE AUTHOR'S CONTRACTUAL AND PROPRIETARY RIGHTS AND BE AT USER'S SOLE RISK AND WITHOUT ANY LIABILITY OR LEGAL RESPONSIBILITY OF MWH.

DRAWING REFERENCE(S):
1. POST–MINE TOPOGRAPHY GENERATED FROM:
- USGS DIGITAL ELEVATION MODELS (DEM)–24K.
- SURVEY DATA FOR BALLARD MINE PROVIDED BY OLYMPUS AERIAL SURVEYS, INC. DATED: JUNE 2005.
- SURVEY DATA FOR HENRY MINE AREA PROVIDED BY OLYMPUS AERIAL SURVEYS, INC. DATED: NOVEMBER 2008.
- SURVEY DATA FOR ENOCH VALLEY MINE AREA PROVIDED BY P4 PRODUCTION DATED: DECEMBER 2007.
- US CENSUS BUREAU 2007 TIGER LINE DATA

PROJECTION:
STATE PLANE COORDINATE SYSTEM
ZONE:
IDAHO EAST
HORIZONTAL DATUM:
NAD27
VERTICAL DATUM:
NGVD29
UNITS:
U.S. FEET

DESIGNED BY	C FOULK	09/17/13
DRAWN BY	C FOWLER	09/17/13
CHECKED BY	C FOULK	09/17/13
APPROVED BY	C FOULK	09/17/13
PROJECT MANAGER	V DRAIN	
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

P4 Production, LLC

PROJECT LOCATION
BALLARD MINE SITE

PROJECT
BALLARD MINE FEASIBILITY STUDY

TITLE
EAST SIDE OF MINE
DIRECT PUSH SELENIUM ISOCONCENTRATION MAP

MWH

DRAWING 2-7
REVISION 0
FILE NAME 10502806D013-F

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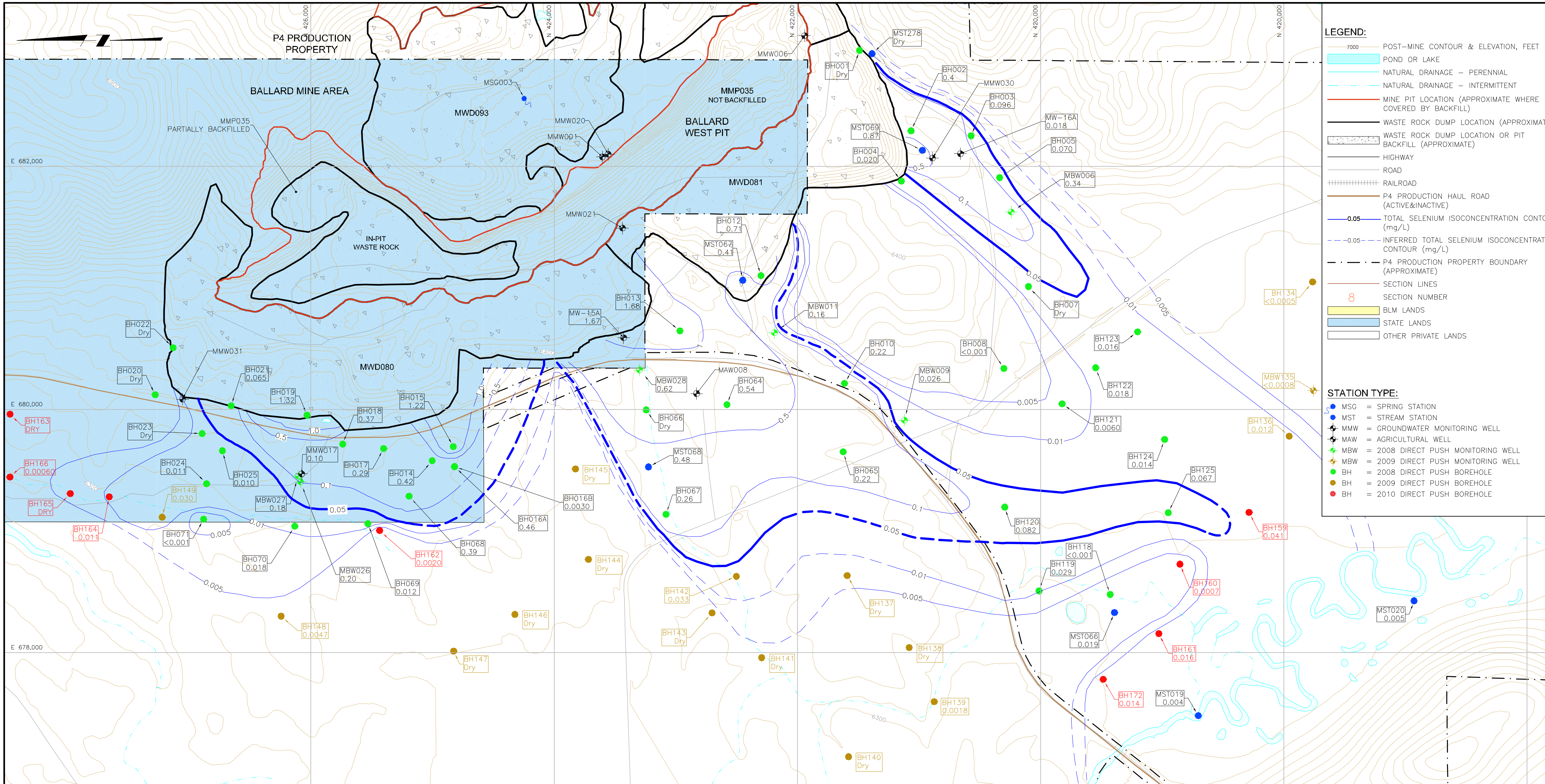

KEY:

MMP = MINE PIT
MWD = WASTE ROCK DUMP

BH043 0.010	2008 DIRECT PUSH BOREHOLE ID AND DISSOLVED SELENIUM CONCENTRATION
BH043 0.010	2009 DIRECT PUSH BOREHOLE ID AND DISSOLVED SELENIUM CONCENTRATION
BH159 0.041	2010 DIRECT PUSH BOREHOLE ID AND DISSOLVED SELENIUM CONCENTRATION
<0.001	CONCENTRATION LESS THAN THE METHOD DETECTION LIMIT

NOTES:

1. WHERE WELLS ARE NESTED IN THE ALLUVIAL FLOW SYSTEM (I.E. SHALLOW AND DEEPER) THE HIGHEST MEASURED CONCENTRATION IS USED FOR CONTOURING.
2. SPRING 2008 TOTAL SELENIUM CONCENTRATIONS ARE USED FOR MONITORING WELLS, SPRINGS AND HEADWATER STREAMS WHERE APPROPRIATE.
3. ISOCONCENTRATION CONTOUR INTERVAL=LOG WITH SUPPLEMENTAL HALF CYCLE CONTOURS.
4. BEDROCK WELLS ARE SHOWN FOR REFERENCE. SELENIUM CONCENTRATIONS ARE NOT SHOWN FOR THESE WELLS.
5. MST019, MST020 AND MST066 ARE SURFACE WATER SAMPLES AND ARE NOT USED IN CONTOURING, NOR ARE THEY DIRECTLY RELATED TO GROUNDWATER SELENIUM DISTRIBUTION.

SCALE 400' 0 400' 800'
CONTOUR INTERVAL = 20'

ISSUE / REV	DESCRIPTION	TECH	ENG	DATE
0	ISSUED DRAFT FOR CLIENT REVIEW	CHF	CLF	

DISCLAIMER:
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DRAWING REFERENCE(S):
1. POST–MINE TOPOGRAPHY GENERATED FROM:
- USGS DIGITAL ELEVATION MODELS (DEM)–24K.
- SURVEY DATA FOR BALLARD MINE PROVIDED BY OLYMPUS AERIAL SURVEYS, INC. DATED: JUNE 2005.
- SURVEY DATA FOR HENRY MINE AREA PROVIDED BY OLYMPUS AERIAL SURVEYS, INC. DATED: NOVEMBER 2008.
- SURVEY DATA FOR ENOCH VALLEY MINE AREA PROVIDED BY P4 PRODUCTION DATED: DECEMBER 2007.
- US CENSUS BUREAU 2007 TIGER LINE DATA

PROJECTION: STATE PLANE COORDINATE SYSTEM
ZONE: IDAHO EAST
HORIZONTAL DATUM: NAD27
VERTICAL DATUM: NGVD29
UNITS: U.S. FEET

DESIGNED BY	C FOULK	09/17/13
DRAWN BY	C FOWLER	09/17/13
CHECKED BY	C FOULK	09/17/13
APPROVED BY	C FOULK	09/17/13
PROJECT MANAGER	V DRAIN	
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

P4 Production, LLC

PROJECT LOCATION: BALLARD MINE SITE
PROJECT: BALLARD MINE FEASIBILITY STUDY
TITLE: WEST SIDE OF MINE DIRECT PUSH SELENIUM ISOCONCENTRATION MAP

MWH

DRAWING 2-8 REVISION 0
FILE NAME 10502806D014-F

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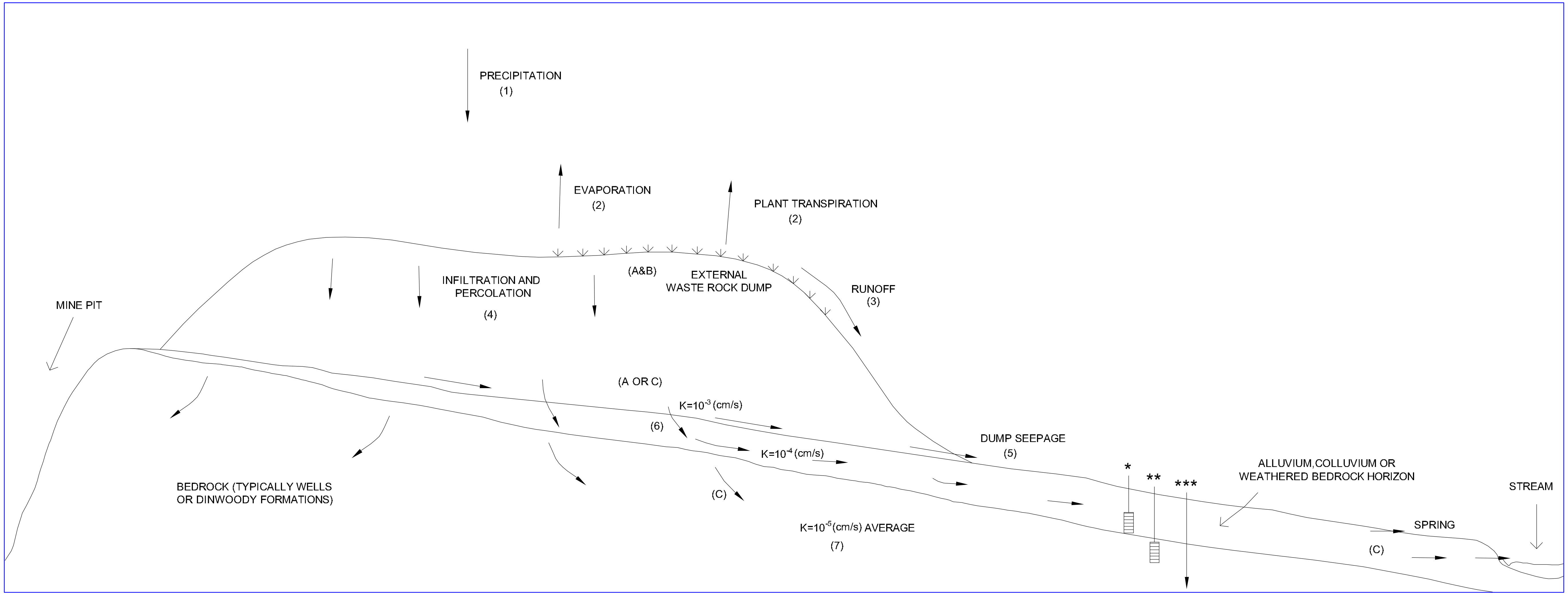

NOT TO SCALE

HYDROLOGICAL PROCESSES (WITH EXAMPLE FLUXES)

1. PRECIPITATION = 2.4 GPM/ACRE BASED ON 23.64 INCHES/YEAR AVERAGE
2. EVAPOTRANSPIRATION = ESTIMATED TO BE 1.2 TO 1.7 GPM/ACRE OR 50 TO 70% OF TOTAL PRECIPITATION (COMBINED EVAPOTRANSPIRATION)
3. RUNOFF = ESTIMATED TO BE 0.24 TO 0.48 GPM/ACRE OR 10 TO 20% OF TOTAL PRECIPITATION (BASED ON SLOPES FROM 2–33%)
4. INFILTRATION = ESTIMATED TO BE 0.36 TO 0.72 GPM/ACRE OR 15 OR 30% OF TOTAL PRECIPITATION
5. SEEPAGE = ESTIMATED TO BE 0.32 TO 0.65 GPM/ACRE BASED ON ASSUMED 10X HIGHER K COMPARED TO UNDERLYING UNIT
6. INFILTRATION TO ALLUVIUM = 0.04 TO 0.07 GPM/ACRE
7. INFILTRATION TO BEDROCK = 0.004 TO 0.007 GPM/ACRE
   (RATES ESTIMATED BASED ON MODELING AND ASSUMPTIONS)

GEOCHEMICAL/BIOLOGICAL PROCESSES

A. LEACHING OF SOLUBLE SELENIUM
B. OXIDATION OF SULFIDES
C. BIOLOGICAL REDUCTION OF SELENIUM AND ADSORPTION AND PRECIPITATION

WASTE ROCK DUMP LOCATIONS

MWD080,MWD081,MWD083,MWD084,MWD082

WELL LOCATIONS

* ALLUVIAL – MMW017,MW–15A,MW–16A,MBW WELLS
** WEATHERED DINWOODY – MMW018,MMW029,MMW032
*** DEEP DINWOODY – MMW033

ISSUE/REV	DESCRIPTION	TECH	ENG	DATE
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DESIGNED BY	C FOULK	09/17/13
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CHECKED BY	C FOULK	09/17/13
APPROVED BY	C FOULK	09/17/13
PROJECT MANAGER	V DRAIN	
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

P4 Production, LLC

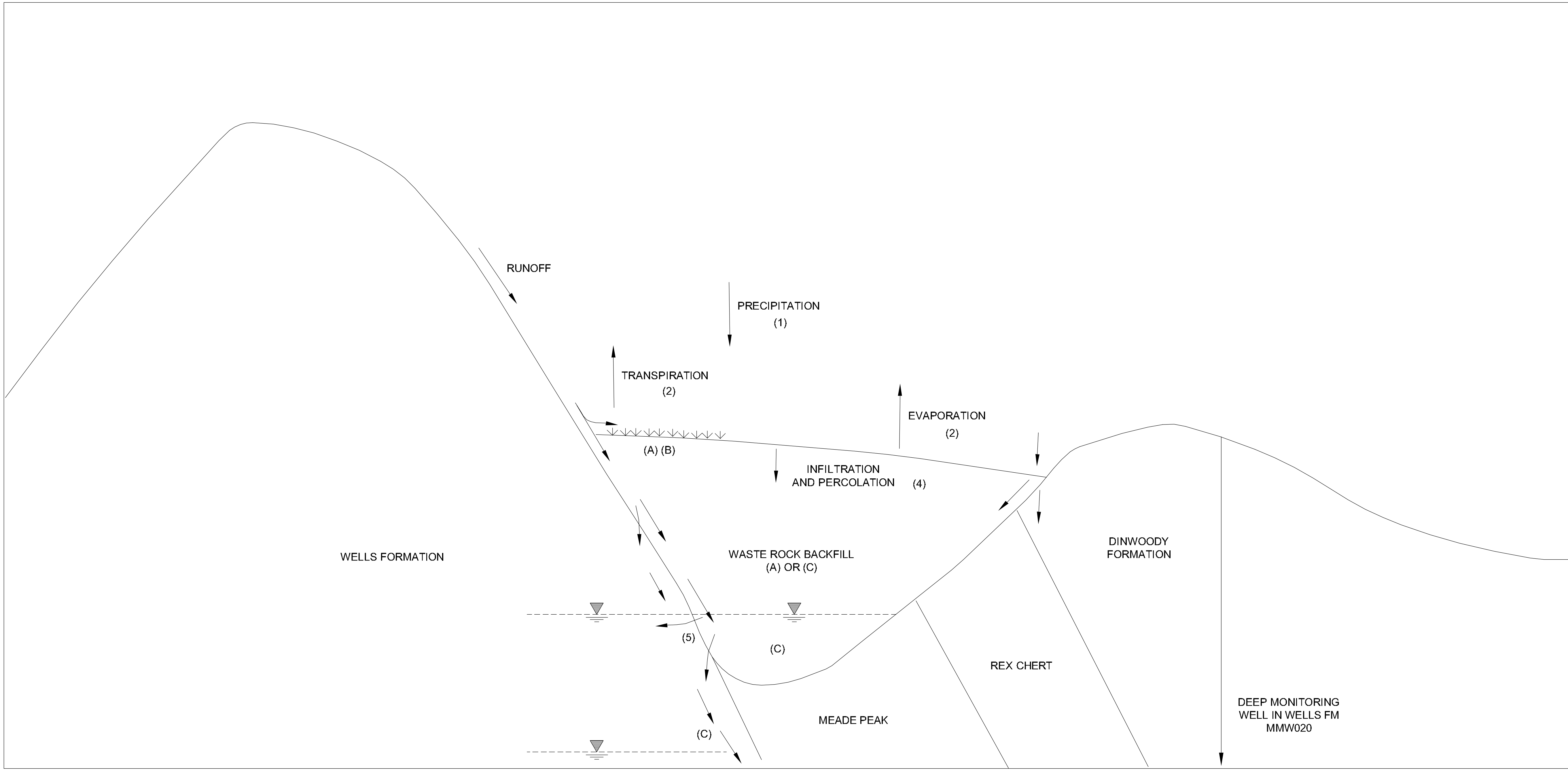
PROJECT LOCATION: BALLARD MINE SITE

PROJECT: BALLARD MINE FEASIBILITY STUDY

TITLE: CONCEPTUAL MODEL
GENERIC EXTERNAL WASTE ROCK DUMP

MWH

DRAWING: 2-9
REVISION: 0
FILE NAME: 10502806D015-F



NOT TO SCALE

HYDROLOGICAL PROCESSES

1. PRECIPITATION = 2.4 GPM/ACRE BASED ON 23.64 INCHES/YEAR AVERAGE
2. EVAPOTRANSPIRATION = ESTIMATED TO BE 1.2 TO 1.7 GPM/ACRE OR 50 TO 70% OF TOTAL PRECIPITATION (COMBINED EVAPORTRANSPIRATION)
3. RUNOFF = ESTIMATED TO BE 0.24 TO 0.48 GPM/ACRE OR 10 TO 20% OF TOTAL PRECIPITATION(BASED ON SLOPES FROM 2-33%)
4. INFILTRATION = ESTIMATED TO BE 0.36 TO 0.72 GPM/ACRE OR 15 OR 30% OF TOTAL PRECIPITATION
5. INFILTRATION TO BEDROCK = 0.004 TO 0.007 GPM/ACRE (GROUNDWATER IN PIT MAY BE PERCHED)

(RATES ESTIMATED BASED ON MODELING AND ASSUMPTIONS)

GEOCHEMICAL/BIOLOGICAL PROCESSES

A. LEACHING OF SOLUBLE SELENIUM
B. OXIDATION OF SULFIDES
C. BIOLOGICAL REDUCTION OF SELENIUM AND ADSORPTION AND/OR PRECIPITATION

ISSUE/REV	DESCRIPTION	TECH	ENG	DATE
0	ISSUED DRAFT FOR CLIENT REVIEW	CHF	CLF	

DESIGNED BY	C FOULK	09/17/13
DRAWN BY	C FOWLER	09/17/13
CHECKED BY	C FOULK	09/17/13
APPROVED BY	C FOULK	09/17/13
PROJECT MANAGER	V DRAIN	
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

P4 Production, LLC

PROJECT LOCATION: BALLARD MINE SITE

PROJECT: BALLARD MINE FEASIBILITY STUDY

TITLE: CONCEPTUAL MODEL GENERIC BACKFILLED MINE PIT

MWH

DRAWING: 2-10

REVISION: 0

FILE NAME: 10502806D016-F

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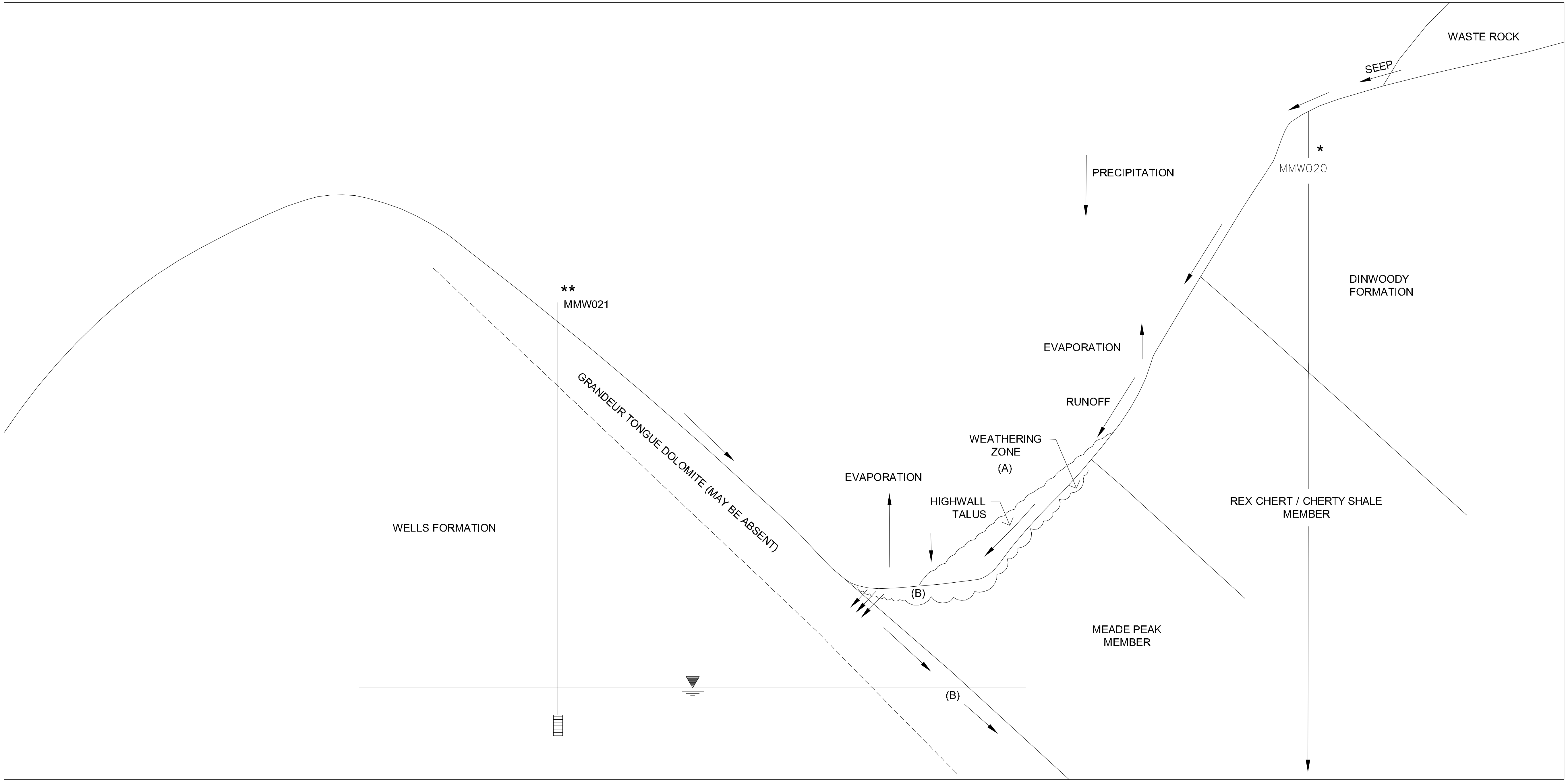

NOT TO SCALE

LEGEND:

WATER FLOW VECTOR

GEOCHEMICAL/BIOLOGICAL PROCESSES

A. LEACHING OF SOLUBLE SELENIUM AND OXIDATION OF SULFIDES
B. BIOLOGICAL REDUCTION OF SELENIUM AND ADSORPTION AND PRECIPITATION

WELL LOCATIONS

* UPPER WELLS FM.– MMW020
** DEEPER WELLS FM. – MMW021

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ISSUE / REV	DESCRIPTION	TECH	ENG	DATE
0	ISSUED DRAFT FOR CLIENT REVIEW	CHF	CLF	09/17/13

DESIGNED BY	C FOULK	09/17/13
DRAWN BY	C FOWLER	09/17/13
CHECKED BY	C FOULK	09/17/13
APPROVED BY	C FOULK	09/17/13
PROJECT MANAGER	V DRAIN	
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

P4 Production, LLC

PROJECT LOCATION
BALLARD MINE SITE

PROJECT
BALLARD MINE FEASIBILITY STUDY

TITLE
CONCEPTUAL MODEL
GENERIC OPEN MINE PIT

MWH

DRAWING 2-11
REVISION 0
FILE NAME 10502806D017-F

3 REMEDIAL ACTION OBJECTIVES, ARARS, GENERAL RESPONSE ACTIONS, AND PRELIMINARY CLEANUP LEVELS

3.1 INTRODUCTION

This section provides the supporting information and rationale for development of ARARs, RAOs and GRAs. These items were initially identified in the *P4 Sites RI/FS Work Plan* in order to assist with data gap evaluation. These preliminary ARARs, RAOs, and GRAs were further evaluated based on the findings of the *Ballard Mine RI Report* in order to support evaluation of technologies and alternatives in this FS. The final list of GRAs are presented in this section. The ARARs and RAOs presented are preliminary and will be finalized in the ROD that will be prepared for the Site. Preliminary cleanup levels that will serve as the foundation for meeting RAOs in each medium are also provided herein.

3.2 REVIEW OF THE ARARs BASED ON RI FINDINGS

3.2.1 CERCLA Provision Requiring Remedial Actions to Meet ARARs

The requirement for identifying and meeting ARARs is established by CERCLA Section 121 (d)(2)(A), which states the following:

> "*With respect to any hazardous substance, pollutant or contaminant that will remain on-site, if – (i) any standard, requirement, criteria, or limitation under any Federal environmental law"….. "; or (ii) any promulgated standard, requirement, or limitation under a State environmental or siting law that is more stringent than any Federal standard, requirement, criteria, or limitation"...... "and that has been identified" …… "in a timely manner, is legally applicable to the hazardous substance or pollutant or contaminant concerned or is relevant and appropriate under the circumstances of the release or threatened release of such hazardous substance or pollutant or contaminant, the remedial action selected ... shall require, at the completion of the remedial action, a level or standard of control for such hazardous substance or pollutant or contaminant which at least attains such legally applicable or relevant or appropriate standard, requirement, criteria, or limitation.*"

CERCLA also exempts certain substantive standards from classification as ARARs, for example standards that are not of general applicability or have not been consistently applied in other similar circumstances (USEPA, 1988b).

3.2.2 Evaluation of Site-Specific ARARs

ARARs are substantive requirements that are either directly applicable or relevant and appropriate to actions or conditions at the Site. A requirement is applicable if it is legally binding to a site condition and directly addresses the contaminants, locations or actions involved in the RA.

A requirement may be relevant and appropriate if circumstances at the Site are similar to the problems or situations intended to be addressed by the requirement.

ARARs do not include administrative requirements that facilitate the implementation of the substantive requirements of a statute or regulation. Examples of administrative requirements are approvals, consultations with administrative bodies, and agency exemption or variance processes.

As discussed in the NCP preamble at 55 FR 8741 (March 8, 1990), ARARs fall into three categories.

- *Chemical-Specific*: These are health- or risk-based criteria that define permissible concentrations of chemicals for various environmental media.
- *Action-Specific*: These requirements specify how a specific RA must be conducted or the performance criteria it must achieve.
- *Location-Specific*: These requirements may mandate or restrict particular actions solely due to site location, even if the same actions are acceptable elsewhere.

The federal and state chemical-specific ARARs identified for the Site are presented in **Tables 3-1** and **3-2**, respectively. The chemical-specific ARARs generally are used to define concentration limits for particular constituents in environmental media.

The location- and action-specific ARARs presented in **Tables 3-3** and **3-4** are for federal and state sources, respectively. Location- and action-specific ARARs are considered together for federal and state laws because some of these potential ARARs may be both location- and action-specific.

3.3 REMEDIAL ACTION OBJECTIVES

Remedial action objectives (RAOs) are medium-specific or area-specific goals within a Site for protection of human health and the environment (USEPA, 1988a). The NCP specifies that RAOs be developed to address 1) contaminants of concern, 2) media of concern, 3) potential exposure pathways, and 4) preliminary remediation levels or goals. The development of these goals for the Ballard Site involves the evaluation of the results of the *Ballard Mine RI Report* including the BRA and the identification and application of ARARs. The medium-specific RAOs are presented in **Table 3-5**. Ballard FS Memo #2 will assemble GRAs and remedial technologies into remedial alternatives that strive to meet these RAOs.

3.4 GENERAL RESPONSE ACTIONS

GRAs describe those actions that will satisfy the RAOs listed in **Table 3-5**. GRAs may include treatment, containment, excavation, extraction, disposal, institutional controls, or a combination of these to reduce or eliminate contaminant pathways at the Site and protect ecological and human receptors by limiting exposure. Like RAOs, GRAs are medium-specific and include the following general responses:

- No Action
- Institutional Controls
- Containment
- Removal/Disposal
- Ex-situ Treatment
- In-situ Treatment

Potential remedial technologies that satisfy these GRAs are similar for several media (e.g., for upland soil and for sediment) because they are general classes of responses. However, the specific remedial technologies or process options to be utilized for Site remediation will vary depending on the medium to be treated and the site-specific/area-specific conditions. This process of identification and selection of treatment/containment areas and volumes and the appropriate remedial technologies that satisfy general response actions are discussed in more detail for each medium in Section 4.0.

3.5 PRELIMINARY CLEANUP LEVELS BY MEDIUM

Contaminants of concern for human, ecological, and livestock receptors (COCs/ROCs/COECs/LCOCs) are identified in Section 2.5 and are based on the BRA findings presented in Appendix A of the *Ballard Mine RI Report*. Section 3.3 discussed the development of RAOs and **Table 3-5** identifies the RAOs specifically developed for protection of human health and the environment at the Ballard Site.

This subsection describes the development of Site-specific preliminary cleanup levels (PCLs) for the complete list of COCs/ROCs/COECs/LCOCs identified in solid media (i.e., upland soils, riparian soils, and sediment) at the Ballard Site that will be necessary to achieve the RAOs so that acceptable risk levels are attained through the Site remediation. In addition to PCLs for solid media, published performance targets for vegetation to be used for monitoring the effectiveness of the remedy for upland soils/waste rock are provided in this subsection.

The list of COCs/ROCs/COECs/LCOCs in solid media and their PCLs will be further refined during the FS (or remedial design [RD]) process so that a reduced number of indicator constituents can be used during any potential future RAs that are necessary at the Site. (Ultimately, the PCLs presented herein will be established as cleanup levels in the ROD.) These indicator COCs/ROCs/COECs/LCOCs will ensure that when their cleanup levels are reached, the other constituents also would be remediated.

Please note that Site-specific cleanup levels were not developed for groundwater or surface water because the cleanup levels for these media default to ARARs (e.g., MCLs and other applicable standards) as shown in **Table 3-6**. Vegetation is a secondary medium and vegetation targets discussed in this subsection are not equivalent to PCLs but, as noted above, these performance targets may be used to help evaluate the efficacy of the RA for primary media (soils and sediments), as discussed in Section 4.0.

PCLs for solid media (i.e., upland soil, riparian soil, and sediment) were developed in general accordance with CERCLA guidance on development of remediation goals (USEPA, 1997) and are listed in **Table 3-7**. These PCLs are based on Site-specific, risk-based cleanup levels (RBCLs) that are protective of human, ecological, and livestock receptors and were developed using A/T-approved 2013 background values for the various solid media (MWH, 2013), and the updated 2014 background values for upland soil (MWH, 2015a). Site-specific RBCLs were calculated for soil and sediment media using the same human, ecological, and livestock receptors; exposure pathways; and exposure assumptions that were used during the evaluations in the *Ballard BRA* included in the *Ballard Mine RI Report*. Site-specific RBCLs were calculated for each COC/ROC/COEC/LCOC identified in the BRA based on a target cancer risk of 1×10^{-4}, 1×10^{-5}, and 1×10^{-6} for human receptors, and a non-cancer HQ of 1.0 for human, ecological, and livestock receptors.

Background values, human health RBCLs, ecological RBCLs, livestock RBCLs and the PCLs for the complete list of COCs/ROCs/COECs/LCOCs in solid media are summarized in **Table 3-7.** Consistent with the *Ballard BRA*, measured plant data were used to calculate RBCLs where available.

The methods and assumptions used to calculate RBCLs are described in greater detail in **Appendix A**. As noted in this table, the recent pooled 2009 and 2014 background values for upland soil are included and are based on the 95-95 upper tolerance limit (UTL) as specified in the *Background and Radiological Soils Report*. The 95% upper simultaneous limit (USL) was selected as the background statistic for all other media at the Sites, as documented in the *Background Levels Tech Memo*. This statistic will still be used for Site media other than upland soils including riparian soils, sediment, groundwater, and surface water.

Index plots showing the background dataset and select summary statistics, as well as the Ballard Site data, were prepared at the request of the A/Ts following their review of the initial draft of this memorandum (i.e., *Draft Ballard Mine Feasibility Study Report – Memorandum 1- Rev 0)* and are included as an attachment to **Appendix A**.

Each PCL for soil or sediment is set as the most conservative RBCL developed for human, ecological, or livestock receptors unless the background concentration is greater, in which case the background level becomes the PCL. For example, the PCL for antimony in upland soil is 3.60 mg/kg, which is the background antimony concentration. Antimony's background concentration is greater than either the human health RBCL (0.247 mg/kg) or ecological RBCL (0.703 mg/kg) presented in **Table 3-7**. Because cleanup levels are based on either background or the most conservative RBCL that was developed for each COC/ROC/COEC/LCOC, they are protective of any current or future human or ecological receptors at the Ballard Site.

During the collection of on-Site soil samples in 2009 and all background soil samples, five random discrete soil samples were collected and composited to represent a single point. Similarly, during remedial construction, whether defining the limits of contamination or verifying an area has been remediated in upland soil/waste rock areas, P4 will compare each 5-point composite sample directly to the PCLs (which are typically derived from the background 95-95 UTL as shown in **Table 3-7**) to make an "exceeds" or "does not exceed" determination. A sample result exceeding the PCL may be evaluated by further analysis of individual discrete samples comprising the composite sample for hotspot verification sampling and/or further remedial efforts.

In riparian soil and sediment areas, PCLs also will be used where necessary to determine the extent of contamination during remedial construction and whether portions of the Ballard Site have been sufficiently remediated. As the background-based PCLs for both riparian soil and sediment are based on the 95% USL, 5-point composite samples also will be directly compared to PCLs provided in **Table 3-7** to make an "exceeds" or "does not exceed" determination and to evaluate whether additional verification sampling or further remedial efforts are necessary.

As mentioned above, concentrations of COCs/ROCs/COECs/LCOCs in vegetation will be addressed through cleanup of primary media, and published performance targets may be used to evaluate the effectiveness of this RA. Proposed vegetation targets for use at the Ballard Site are presented in **Table 3-8**. The most likely consumers of vegetation at the Ballard Site are grazing animals, including elk or cattle. More literature exists regarding mineral tolerance levels in livestock than in wildlife and, therefore, the ranges of toxic dietary concentrations published by Puls (1994) and Mackowiak et al (2004), as well as the recommended performance targets for the P4 Sites (i.e., NRC Maximum Tolerable Levels), that are presented in **Table 3-6** are for livestock (i.e., cattle, horses, and sheep) in most cases.

Ballard Mine Site: Potential Applicable or Relevant and Appropriate Requirements

The following table presents a list of requirements tentatively identified by P4 Production, L.L.C. ("P4") as potential Applicable or Relevant and Appropriate Requirements ("ARARs") for the Ballard Mine Site pursuant to an Administrative Settlement Agreement and Order on Consent for Performance of Remedial Investigation and Feasibility Study at the Enoch, Henry, and Ballard Mine Sites in Southeastern Idaho dated September 28, 2009. P4 anticipates that this list of potential ARARs will be used in preparing the Feasibility Study for the Ballard Mine, including for the development of preliminary remediation goals and for use as threshold criteria against which remedial alternatives will be evaluated. P4 acknowledges that the following list of potential ARARs are not binding and that final ARARs will be developed by EPA and set forth in the Record of Decision for use as performance standards for the remedial design and remedial action.

Statutes and regulations, and their citations, included in the tables included below are provided as headings to identify general categories of potential ARARs for the convenience of the reader. Listing the statutes and regulations does not indicate acceptance of the entire statute or regulation as potential ARARs; rather only the substantive provisions of the requirements cited in these tables are potential ARARs.

Table 3-1: Federal Chemical Specific ARARs for the Ballard Site

	Statutes, Regulations, Standards, or Requirements	Citations or References	General Description	Site-Specific Comments	Determination
1	National Primary Drinking Water Regulations	40 C.F.R. Part 141	Establishes health-based standards (maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs)) for public water systems.	Potentially relevant and appropriate if groundwater beneath the Site is used to supply public water systems. COCs/COECs and proposed groundwater cleanup levels are provide in Table 3-6.	Potentially relevant and appropriate
2	Water Quality Standards[1]	33 U.S.C. § 1314(a) 40 C.F.R. Part 131	Section 304 of the federal Clean Water Act (33 U.S.C. § 1314) requires that individual states establish water quality standards for surface waters. The implementing regulation establishes the Ambient Water Quality Criteria, which are the minimum requirements for state water quality standards that are protective of aquatic life. Under CERCLA, water quality criteria for the protection of aquatic life are considered relevant and appropriate for actions that involve surface waters or groundwater discharges to surface waters. The federal water quality standards are developed for states to use in development of water quality criteria that incorporate designated uses for specific surface water bodies. The State of Idaho has adopted the federal water quality criteria. Where numeric state water quality standards have not been promulgated, federal numeric water quality standards are considered relevant and appropriate standards. Federal Ambient Water Quality Criteria have been established for short-term exposures (acute criteria) and for long-term exposures (chronic criteria) for protection of aquatic biota.	The State of Idaho has adopted the federal water quality criteria. Where numeric state water quality standards have not been promulgated, federal numeric water quality standards are considered applicable. COCs/COECs and proposed surface water cleanup levels are provide in Table 3-6.	Applicable
3	Resource Conservation and Recovery Act	40 C.F.R. § 261.4(b)(7)	EPA exempts mining wastes from the extraction, beneficiation, and some processing of ores and minerals, in accordance with the Bevill amendment to RCRA.	Waste rock at the Site may meet this exemption.	Applicable

[1] National Recommended Water Quality Criteria are available at http://www.epa.gov/ost/criteria/wqctable/.

Table 3-1: Federal Chemical Specific ARARs for the Ballard Site

	Statutes, Regulations, Standards, or Requirements	Citations or References	General Description	Site-Specific Comments	Determination
4		40 C.F.R. § 261.20	Generators of solid waste must determine whether the waste is hazardous. A solid waste is hazardous if it exhibits the toxicity characteristic (based on extraction procedure Method 1311).	Potentially applicable depending on the selected remedy.	Applicable
5	Uranium Mill Tailings Radiation Control Act (UMTRCA)— Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings	42 U.S.C. §§ 7901 *et seq.* 40 C.F.R. Part 192.02 (a)	Control of residual radioactive materials and their listed constituents will be designed to be effective for at least 200 years.	Potentially relevant and appropriate remedial design criteria for the naturally occurring uranium and daughter products at the Ballard Mine.	Potentially relevant and appropriate

Table 3-2: State Chemical Specific ARARs for the Ballard Site					
	Statutes, Regulations, Standards, or Requirements	**Citations or References**	**General Description**	**Site-Specific Comments**	**Determination**
1	Idaho Water Quality Standards	IDAPA 58.01.02	Surface water quality standards and waste water treatment requirements, including: water quality criteria for aquatic life use designations (.250), designations of surface waters found within Blackfoot Basin (.150), general surface water quality criteria (.200), antidegredation policy (.051), and mixing zone policy (.060).	Water quality standards are potentially applicable for surface waters on-Site or affected by the selected remedy. COCs/COECs and proposed surface water cleanup levels are provide in Table 3-6.	Applicable
2	Idaho Ground Water Quality Rule	IDAPA 58.01.11.200	Protects groundwater for beneficial uses including potable water supplies, establishes use classifications, and establishes water quality criteria for ground water.	Applicable to groundwater at the Site. COCs/COECs and proposed groundwater cleanup levels are provide in Table 3-6.	Applicable
3	Idaho Rules for Public Drinking Water Systems	IDAPA 58.01.08	Regulates quality and safety of public drinking water.	Potentially applicable if any of the Site water is a public drinking water source; otherwise, substantive requirements would likely be relevant and appropriate.	Potentially applicable and/or relevant and appropriate
4	Rules and Standards for Hazardous Waste	IDAPA 58.01.05	Rules and standards for hazardous waste. Identifies characteristic and listed hazardous wastes and provides rules for hazardous waste permits.	Potentially relevant and appropriate if hazardous waste is identified or generated during implementation of the selected remedy.	Potentially relevant and appropriate
5	Rules for the Control of Air Pollution	IDAPA 58.01.01 (including IDAPA 58.01.01.650 and .651)	Rules providing for the control of air pollution in Idaho.	Potentially applicable depending on the selected remedy.	Potentially applicable

Table 3-3: Federal Location and Action Specific ARARs for the Ballard Site						
	Statutes, Regulations, Standards, or Requirements	**Citations or References**	**General Description**	**Site-Specific Comments**	**Determination**	**Location or Action Specific**
1	Mineral Leasing Act	30 U.S.C. §§ 181 *et seq.* 43 C.F.R. Parts 3500and 3590	Regulates leasing, mining, processing and reclamation of federally-owned phosphate deposits.	Provisions regarding reclamation and mineral development are potentially applicable; other provisions may be relevant and appropriate.	Applicable	Action, Location
2	Federal Land Policy and Management Act	43 U.S.C. §§ 1732 *et seq.* .	Prevents unnecessary or undue degradation of public lands by operations authorized by the mining laws. Establishes public land policy and guidelines for the administration of public lands; provides for the management, use, occupancy, and development of public lands.	Provisions regarding multiple use and unnecessary or undue degradation are applicable to the extraction of minerals; other provisions may be relevant and appropriate.	Applicable	Action, Location
3	U.S. Bureau of Land Management Record of Decision and Pocatello Resource Management Plan (April 2012), as amended Sept. 21, 2015	Available online at https://eplanning.blm.gov/epl-front-office/projects/nepa/32803/38812/40712/RODandSIR_508.pdf	To sustain the health, diversity, and productivity of the public lands. The plan provides objectives, land use allocations, and management direction to maintain, improve or restore resource conditions and provide for the economic needs of local communities over the long term. The plan applies to BLM-managed public lands and split estate lands where minerals are federally owned in southeast Idaho.	Should be considered due to BLM's ownership of the mineral rights.	TBC	Action, Location
4	Mine and Reclamation Plans		Operation plans that are approved subsequent to issuing the lease at a time after mining is proposed. Establish mine plans and reclamation requirements.	Should be considered during remedial action, especially if the remedy involves ore recovery.	TBC	Action, Location
5	Fish and Wildlife Coordination Act	16 U.S.C. § 661 *et seq.*	Requires that federal agencies involved in actions that will result in control or modification of any natural stream or water body must protect fish and wildlife resources that may be affected by the actions.	Potentially applicable if remedial actions affect natural streams and water bodies; the selected remedy must be designed and implemented to be protective of fish and wildlife.	Applicable	Location
6	Endangered Species Act	16 U.S.C. §§ 1531 *et seq.* 50 C.F.R. Part 402	Federal Agencies are prohibited from jeopardizing threatened and endangered species or adversely modifying habitats essential to their survival. Requires consultation with the Service charged with protection of the listed species.	May be applicable if on-Site activities may jeopardize threatened or endangered species or adversely modify their habitat.	Applicable	Location (habitat), Action (species)
7	Migratory Bird Treaty Act (MBTA)	16 U.S.C. §§ 703 *et seq.*	Prohibits persons from pursuing, hunting, taking, capturing, killing, attempting to take, capture or kill, possessing, offering for sale, selling, offering to purchase, purchasing, delivering for shipment, shipping, causing to be shipped, delivering for transportation, transporting, causing to be transported, carrying, or causing to be carried by any means whatever, receiving for shipment, transportation or carriage, or exporting migratory birds covered by the MBTA or any part, nest, or egg of any such bird.	Remedial action at the Site must be designed and implemented to avoid harm to migratory birds.	Applicable	Action

Table 3-3: Federal Location and Action Specific ARARs for the Ballard Site						
	Statutes, Regulations, Standards, or Requirements	**Citations or References**	**General Description**	**Site-Specific Comments**	**Determination**	**Location or Action Specific**
8	Bald and Golden Eagle Protection Act	16 U.S.C. §§ 668 *et seq.* 50 C.F.R. Part 22	Prohibits any person from knowingly, or with wanton disregard, selling, offering to sell, taking, purchasing, transferring, bartering, exporting, importing, or possessing or harming a bald or golden eagle, or any part, nest, or egg thereof without obtaining a permit.	Remedial action at the Site must be designed and implemented to avoid harm to bald or golden eagles, their nests, or eggs.	Applicable	Location, Action
9	Clean Water Act	40 C.F.R. § 125.3	Requirements for best treatment and control technology prior to discharge.	May be relevant and appropriate if water treatment is used as part of the selected remedy.	Potentially relevant and appropriate	Action
10		33 U.S.C. § 1342 40 C.F.R. Parts 122-125	The NPDES (also known as Section 402 of the CWA) program establishes a comprehensive framework for addressing waste water and storm water discharges under the program. Requires that point-source discharges not cause the exceedance of surface water quality standards outside the mixing zone. Specifies requirements under 40 C.F.R. § 122.26 for point-source discharge of storm water from construction sites to surface water and provides for Best Management Practices such as erosion control for removal and management of sediment to prevent run-on and runoff.	May be relevant and appropriate if the selected remedy involves discharges from a water treatment plant.	Potentially relevant and appropriate	Action
11		33 U.S.C. § 1344	Requirements for dredging and filling activities conducted in waters of the U.S., including wetlands (also known as Section 404 of the CWA).	May be relevant and appropriate if the selected remedy involves dredging or filling in waters of the U.S.	Potentially relevant and appropriate	Location, Action
12	Clean Air Act	42 U.S.C. §§ 7409 *et seq.* 40 C.F.R. Part 50	Requirements for maintaining air quality.	Potentially applicable depending on the selected remedy.	Potentially applicable	Action
13	National Historic Preservation Act (NHPA)	54 USC 306108 36 C.F.R. Parts 60, 63 and 800	A requirement for a property listed on or eligible for listing on the National Register of Historic Places. The NHPA requires federally funded projects to identify and mitigate impacts of project activities on properties listed on or eligible for listing on the National Register. This statute and implementing regulations require federal agencies to take into account the effect of this response action upon any district, site, building, structure, or object that is listed on or eligible for listing on the National Register of Historic Places (generally, 50 years old or older). If cultural resources listed on or eligible for listing on the National Register are present, it will be necessary to determine if there will be an adverse effect and, if	May be applicable if historic or archeological sites are found within Site boundaries or on land to be disturbed in connection with the selected remedy (*e.g.*, borrow areas).	Potentially applicable	Location

Table 3-3: Federal Location and Action Specific ARARs for the Ballard Site						
	Statutes, Regulations, Standards, or Requirements	**Citations or References**	**General Description**	**Site-Specific Comments**	**Determination**	**Location or Action Specific**
			so, how the effect may be minimized or mitigated, in consultation with the appropriate State Historic Preservation Office.			
14	Archeological and Historic Preservation Act	52 USC 312501 et seq.	The Archaeological and Historic Preservation Act requires that for federally approved projects that may cause irreparable loss to significant scientific, prehistoric, historic, or archaeological data, the data must be preserved by the agency undertaking the project or the agency undertaking the project may request DOI to do so. This statute and implementing regulations establish requirements for the evaluation and preservation of historical and archaeological data, which may be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity or program.	May be applicable if archeological resources are identified.	Potentially applicable	Location
15	Native American Graves Protection and Repatriation Act (NAGPRA)	25 U.S.C. §§ 3001 *et seq.*	Requires federal agencies and institutions that receive federal funding to return Native American cultural items to lineal descendants and culturally affiliated Indian tribes. NAGPRA also establishes procedures for the inadvertent discovery or planned excavation of Native American cultural items on federal or tribal lands.	May be potentially relevant and appropriate if cultural items are identified.	Potentially relevant and appropriate	Location
16	RCRA— Requirements for Hazardous Waste Transport	42 U.S.C. §§ 6901 *et seq.* 40 C.F.R. Parts 261-262	Requirements for handling and transporting hazardous waste.	Potentially relevant and appropriate depending on selected remedy.	Potentially relevant and appropriate	Action
17	RCRA – Requirements for Classification of Solid Waste Disposal Facilities	40 C.F.R. Part 257	Requirements for solid waste disposal facilities and practices, such as restrictions to the base flow of a flood plain, not taking threatened and endangered species, and not causing a discharge to navigable waters.	Potentially relevant and appropriate depending on selected remedy.	Potentially relevant and appropriate	
18	Considering Wetlands at CERCLA Sites	OSWER 9280.03, May 1994	EPA guidance regarding the potential impacts of response actions on wetlands at Superfund sites.	May be helpful if Site remediation contains wetlands.	TBC	Action

Table 3-4: State Location and Action Specific ARARs for the Ballard Site

	Statutes, Regulations, Standards, or Requirements	Citations or References	General Description	Site-Specific Comments	Determination	Location or Action Specific
1	Protection of Birds	Idaho Code Ann. § 36-1102	Prohibits the "take" or intentional disturbance or destruction of eggs or nests of any "game, song, rodent killing, insectivorous or other innocent bird." The prohibition does not apply to English Sparrows or starlings.	Potentially applicable during remedial action.	Potentially applicable	Action
2	Non-point Source Discharges	IDAPA 58.01.02.350	Regulates non-point source discharges, designates approved BMPs and provides additional protection for outstanding resource waters.	May be applicable if the selected remedy results in non-point source discharges.	Potentially applicable	Action
3	Point Source Discharges	IDAPA 58.01.02.400-.401	Provides limits and restrictions including possible limits on temperature and flow rates for point source discharges.	May be applicable if the selected remedy results in point source discharges.	Potentially applicable	Action
4	Storage of Hazardous and Deleterious Materials	IDAPA 58.01.02.800	Prohibits the storage, disposal or accumulation of hazardous and deleterious materials "adjacent to or in the immediate vicinity of state waters" without adequate measures and controls to insure the materials will not enter state waters.	May be relevant and appropriate if the remedial action results in the storage of hazardous and deleterious materials near state waters.	Potentially relevant and appropriate	Action
5	Well Construction Standard Rules	IDAPA 37.03.09	Regulates well construction and abandonment.	May be applicable if the selected remedy includes additional wells.	Potentially applicable	Action
6	Best Management Practices and Reclamation for Surface Mining Operations	IDAPA 20.03.02.140	Provides BMP and reclamation standards for surface mining operations, including sand and gravel mining.	May be applicable depending on the selected remedy. BMPs may also be relevant and appropriate to remediation activities (i.e. grading, re-contouring, and revegetation).	Potentially applicable and/or relevant and appropriate	Action
7	Idaho Water Quality Standards and Wastewater Treatment Requirements	IDAPA 58.01.02	Requirements for actions involving effluent discharges to surface water.	May be applicable if water treatment is part of the selected remedy.	Potentially applicable	Action
8	Solid Waste Management Rules	IDAPA 58.01.06	Provides substantive requirements for operation and closure of solid waste management facilities.	Only material uniquely associated with phosphate mining is being addressed in the remediation so these requirements are not applicable because the Site is not a solid waste management facility. See IDAPA 58.01.06.001.03(b)(iv). Some requirements may be relevant and appropriate with regard to regulated solid waste generated during the remedial action.	Potentially relevant and appropriate	Action
9	Hazardous Waste and Hazardous Waste Management Act of 1983	IDAPA 58.01.05 1993 Session Law, Ch. 291, Sections 1-8	Adopts federal RCRA regulations concerning the identification of hazardous waste and standards applicable to generators and transporters of hazardous waste as well as	Potentially applicable for management of investigation derived wastes and remediation wastes.	Potentially applicable	Action

Table 3-4: State Location and Action Specific ARARs for the Ballard Site						
	Statutes, Regulations, Standards, or Requirements	**Citations or References**	**General Description**	**Site-Specific Comments**	**Determination**	**Location or Action Specific**
			standards for owners and operators of hazardous waste treatment, storage and disposal facilities.			
10	Fences in General (LEAs)	Idaho Code §§ 35-101 to -112	Establishes construction requirements, such as height and distance between posts, for all types of fences. Defines who is responsible for construction and maintenance of enclosure and partition fences.	May be applicable if fencing is required to protect components of the selected remedy (e.g., a cover system).	Potentially applicable	Action
11	Idaho Rules for Control of Fugitive Dust	IDAPA 58.01.01.650-651	Provides practices for controlling fugitive dust emissions, including use of water or chemicals, application of dust suppressant, and covering trucks.	May be applicable during remedial action if construction practices generate fugitive dust.	Potentially applicable	Action
12	Idaho Toxic Air Pollutants	IDAPA 58.01.01.585-586	Requirements for maintaining air quality (none currently nor will they be likely associated with any remedial action).	Potentially applicable depending on the selected remedy.	Potentially applicable	Action
13	Preservation of Historical Sites	Idaho Code §§ 67-4111 to -4131 and 67-4601 to -4619	Requirements for protection of public lands and preservation of historical or archaeological sites in consideration of waste disposal.	Requirements may be applicable if historical or archeological sites are present and/or may be disturbed during the remedial action.	Potentially applicable	Location
14	Stream Channel Alteration Rules	IDAPA 37.03.07.055	Provides substantive construction standards for working in stream channels.	Potentially applicable depending on selected remedy; however, procedural requirements are not ARAR.	Potentially applicable	Action
15	Idaho Classification and Protection of Wildlife Rule	IDAPA 13.01.06.300	Classifies fish and wildlife species; identifies threatened or endangered species; and specifies wildlife species that are protected from taking and possessing.	To be considered during ecological risk assessment.	TBC	Location
16	Idaho Uniform Environmental Covenants Act	Idaho Code §§55-3001 to -3015	Allows recordation of an environmental covenant, which is a written agreement where the parties bind themselves, and their successors in interest to the land, to comply with activity and use limitations.		Applicable	Action
17	IDEQ Area Wide Risk Management Plan	IDEQ (2004a)	Recommends removal action goals for addressing releases and impacts from historical phosphate mining operations in southeast Idaho.	May be taken into consideration in developing removal action goals.	TBC	Action
18	Variances from water quality standards	IDAPA 58.01.02.260	Establishes procedures and requirements for obtaining a water quality variance.	Potentially applicable if Site-specific variances are proposed for a particular location or source.	Potentially applicable	Action
19	Idaho Risk Evaluation Manual	IDEQ (2004b) Available online at https://www.deq.idaho.gov/media/967298-risk_evaluation_manual_2004.pdf	Provides guidelines and criteria to apply in risk-based decision making.	Framework for decision making should be considered in developing human and environmental risk-based cleanup levels	TBC	Action

TABLE 3-5
REMEDIAL ACTION OBJECTIVES FOR THE BALLARD SITE

Environmental Medium	Potential Receptor	Remedial Action Objectives
Mine Waste Rock and Upland Soils	Human Health	Prevent or reduce human exposure via all potential exposure pathways (external gamma radiation, inhalation of radon in potential future buildings, incidental ingestion, dermal contact, fugitive dust inhalation, and uptake by plants, wild game, and livestock) associated with waste rock and upland soils that are contaminated with COCs/ROCs exceeding the agreed-upon cleanup levels to achieve acceptable human health risk levels, assuming current or reasonably anticipated future land use, wherever practicable.
		Prevent or reduce release and migration of COCs/ROCs from waste rock and upland soils to groundwater and surface water resulting in concentrations exceeding the higher of ARARs or site-specific background levels, wherever practicable.
	Environment	Prevent or reduce exposure via all potential exposure pathways (ingestion, uptake by plants) associated with waste rock and upland soils that are contaminated with COECs exceeding the agreed-upon cleanup levels to achieve acceptable ecological risk levels, wherever practicable.
		Prevent or reduce release and migration of COECs from waste rock and upland soils to surface water at concentrations exceeding ARARs, or site-specific background levels if ARARs are more stringent than background, wherever practicable.
In-Stream Sediments and Riparian Overbank Deposits	Human Health	Prevent or reduce human exposure via all potential exposure pathways (uptake by plants) associated with sediments and riparian overbank deposits contaminated with COCs exceeding the agreed-upon cleanup levels to achieve acceptable human health risk levels, assuming current or reasonably anticipated future land use, wherever practicable.
	Environment	Prevent or reduce exposure via all potential pathways (ingestion, uptake by plants) associated with sediments and riparian overbank deposits that are contaminated with COECs exceeding the agreed-upon cleanup levels to achieve acceptable ecological risk levels, wherever practicable.
Vegetation	Human Health	Prevent or reduce exposure via all potential exposure pathways (ingestion) associated with vegetation contaminated with COCs exceeding performance targets to achieve acceptable human health risk levels, assuming current or reasonably anticipated future land use, wherever practicable.
	Environment	Prevent or reduce exposure via all potential exposure pathways (ingestion) associated with vegetation contaminated with COECs exceeding performance targets to achieve acceptable ecological risk levels, wherever practicable.
Surface Water in Streams and Ponds	Human Health	Prevent or reduce exposure via all potential exposure pathways (ingestion, dermal contact, uptake by plants, wild game, and livestock) associated with surface water that is contaminated with COCs exceeding the higher of ARARs or site-specific background levels, assuming current or reasonably anticipated future land use, wherever practicable.
	Environment	Prevent or reduce exposure via all potential exposure pathways (ingestion, uptake by plants) associated with surface water exceeding the higher of ARARs for COECs or site-specific background levels wherever practicable.
Groundwater	Human Health	Prevent or reduce exposure via all potential exposure pathways (ingestion, washing/bathing, irrigation of plants, livestock watering) associated with groundwater contaminated with COCs exceeding the higher of ARARs, or site-specific background levels, assuming current or reasonably anticipated future land use, wherever practicable.

TABLE 3-5
REMEDIAL ACTION OBJECTIVES FOR THE BALLARD SITE

Environmental Medium	Potential Receptor	Remedial Action Objectives
Groundwater (continued)	Human Health (continued)	Prevent or reduce further migration of the contaminant plume exceeding the higher of ARARs for COCs, or site-specific background levels, assuming current or reasonably anticipated future land use, wherever practicable.
		Restore groundwater that has been impacted by the Site to meet the higher of ARARs for COCs, or site-specific background levels, assuming current or reasonably anticipated future land use, wherever practicable.
	Environment	Prevent or reduce discharge of groundwater to surface waters at concentrations exceeding the higher of surface water ARARs for COCs, or site-specific background levels, wherever practicable.

Table 3-6
Proposed Surface Water and Groundwater Cleanup Levels

Media COC / COEC	**Current Background Concentration**[a]	**Pending Proposed Cleanup Level**	**ARAR**
Surface Water[b]			
Arsenic	0.00109	0.01	IDAPA 58.01.02
Cadmium	0.00010	0.0006	IDAPA 58.01.02
Selenium	0.000772	0.005	IDAPA 58.01.02
Groundwater[c]			
Arsenic	0.00103	0.01	MCL
Cadmium	0.000401	0.005	MCL
Selenium	0.00278	0.05	MCL

Notes:

All concentrations are milligrams per liter (mg/l).

[a] Background concentration is equal to the 95% USL of background

[b] State of Idaho Surface Water Quality for Aquatic Life (IDAPA 58.01.02); CCC or Water & Organisms (IDEQ, 2013a)

[c] USEPA MCL, National Primary Drinking Water Regulations

ARAR - applicable, relevant, and appropriate requirement
CCC - criterion continuous concentration
MCL - primary maximum contaminant level
NC - not calculated
USL - upper simultaneous limit

Table 3-7
Proposed Soil and Sediment Cleanup Levels

Primary Media COC/ROC/COEC/LCOC	Background Value [b]	Cumulative Human Health RBCL [a]					Cumulative Ecological RBCL [a]											Livestock RBCL [a]	
		Current/Future Native American	Hypothetical Future Resident	Current/Future Seasonal Rancher	Current/Future Camper/Hiker	Current/Future Recreational Hunter	Deer Mouse	American Robin	American Goldfinch	Long-Tailed Vole	Northern Harrier	Coyote	Elk	Mink	Great Blue Heron	Mallard	Raccoon	Beef Cattle	Proposed PCL [c]
Upland Soil																			
Antimony	3.60	**0.247**	0.247	28.1	2,912	3,425	0.703	NA	NA	3.15	NA	34.2	6,943	--	--	--	--	--	3.60
Arsenic	15.6	1.31	**1.26**	11.2	2,074	3,104	--	--	--	--	--	--	--	--	--	--	--	--	15.6
Cadmium	41.0	8.99	14.8	81.4	8,861	10,801	**1.28**	3.00	38.2	38.2	290	503	63,265	--	--	--	--	--	41.0
Chromium	410	--	--	--	--	--	86.3	**74.3**	90.4	247	728	2,114	440,862	--	--	--	--	--	410
Copper	51.9	--	--	--	--	--	110	**74.5**	88.7	195	2,052	7,198	317,302	--	--	--	--	--	74.5
Molybdenum	29.0	31.0	2.62	61.5	59,092	78,011	1.37	25.3	13.0	**0.895**	50.0	14.1	1,398	--	--	--	--	--	29.0
Nickel	220	--	--	--	--	--	**20.7**	77.5	197	112	2,489	1,489	189,385	--	--	--	--	--	220
Radium-226	15.1	**0.244**	0.244	5.41	20.8	13.0	--	--	--	--	--	--	--	--	--	--	--	--	15.1
Selenium	29.0	1.23	3.61	42.4	47,017	58,280	0.864	2.70	1.30	**0.605**	72.1	92.8	946	--	--	--	--	25	29.0
Thallium	1.10	0.404	0.0440	**0.0345**	118	156	0.0400	3.78	6.07	0.0884	36.26	1.30	142	--	--	--	--	--	1.10
Uranium	36.0	**0.439**	65.8	275	7,087	9,348	--	--	--	--	--	--	--	--	--	--	--	--	36.0
Vanadium	300	--	--	--	--	--	552	20.6	**12.1**	483	249	5,696	877,540	--	--	--	--	--	300
Zinc	1,200	--	--	--	--	--	1,028	**729**	1,426	2,562	100,200	134,182	[d]	--	--	--	--	--	1,200
Riparian Soil [e]																			
Arsenic	5.93	**0.110**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5.93
Cadmium	5.02	**7.24**	--	--	--	--	--	--	--	--	--	--	--	8.66	8.74	--	181	--	7.24
Chromium	43.3	--	--	--	--	--	--	--	--	--	--	--	--	**26.1**	238	--	2,461	--	43.3
Copper	24.3	--	--	--	--	--	--	--	--	--	--	--	--	**9.90**	220	--	4,410	--	24.3
Molybdenum	0.653	3.23	--	--	--	--	--	--	--	--	--	--	--	**0.495**	56.3	--	53.4	--	0.653
Nickel	29.6	13.9	--	--	--	--	--	--	--	--	--	--	--	**11.6**	206	--	960	--	29.6
Selenium	2.03	15.5	--	--	--	--	--	--	--	--	--	--	--	**0.110**	17.0	--	105	--	2.03
Thallium	0.483	**0.00734**	--	--	--	--	--	--	--	--	--	--	--	0.0373	10.0	--	2.09	--	0.483
Vanadium	57.9	**3.63**	--	--	--	--	--	--	--	--	--	--	--	81.5	204	--	7,916	--	57.9
Sediment [e]																			
Antimony	5.00 [f]	--	--	--	--	--	--	--	--	--	--	--	--	**0.123**	NA	NA	25.8	--	5.00
Arsenic	4.55 [f]	**2.33**	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	4.55
Cadmium	4.17	**0.828**	--	--	--	--	--	--	--	--	--	--	--	1.73	81.5	486	1,013	--	4.17
Copper	25.5 [f]	--	--	--	--	--	--	--	--	--	--	--	--	**0.831**	352	3,595	11,233	--	25.5
Molybdenum	<0.5	--	--	--	--	--	--	--	--	--	--	--	--	**0.541**	55.9	226	88.0	--	0.541
Selenium	1.48	4.70	--	--	--	--	--	--	--	--	--	--	--	**0.212**	8.89	16.8	42.6	--	1.48
Thallium	0.378 [f]	--	--	--	--	--	--	--	--	--	--	--	--	**0.00770**	5.53	24.1	1.68	--	0.378
Vanadium	49.1	--	--	--	--	--	--	--	--	--	--	--	--	206	**113**	285	7,707	--	113

Table 3-7
Proposed Soil and Sediment Cleanup Levels

Notes:

All concentrations are in units of milligrams per kilogram (mg/kg) with the exception of radium-226, which are in picoCuries per gram (pCi/g).
Bold values indicates the lowest, most conservative human health, ecological, or livestock receptor RBCL

[a] The Human Health RBCL for arsenic and radium-226 are based on a target cancer risk of 1x10-4; all other human, ecologoical and livestock RBCLs are based on a target hazard quotient of 1. The 1x10-5 and 1x10-6 cancer risks can be determined by dividing the 1x10-4 RBCL by 10 and 100, respectively.

[b] The 95-95 UTL was selected as the proposed background level for upland soils collected in 2009 and 2014. The 95% USL was selected as the proposed background level for sediment and riparian soil datasets collected in 2004 and 2010.

[c] The PCL is equal to the greater of the background concentration or the most conservative human health, ecological, or livestock RBCL.

[d] Concentration exceeds 1,000,000 milligrams per kilogram - adverse health effects are negligble

[e] The evaluation of remedial alternatives for riparian soil and sediment are combined in Section 4.0 of this FS because it is likely that these media will have the same selected remedy as they are adjacent and contiguous. Potential future remedial activities in the sediment/riparian corridors at the Site likely will have to consider a single, unified cleanup list of cleanup levels for these media because of their proximity.

[f] The 95% USL was selected as the proposed background level for sediment and riparian soil datasets containing five or more detections. When a dataset contained fewer than five detections, the maximum detected concentration was proposed as the background level. If there were no detected results in a dataset, the maximum detection limit for non-detects was proposed as the background level.

-- not applicable; the analyte was not a COC/ROC/COEC/LCOC in that medium.
COC - contaminant of concern
COEC - contaminant of ecological concern
LCOC - livestock contaminant of concern
ROC - radionculide of concern
PCL - Proposed Cleanup Level
RBCL - risk-based cleanup level
USL - upper simultaneous limit
UTL - upper thresold limit

Table 3-8
Proposed Vegetation Performance Targets

Upland Soil COC/ROC/COEC/LCOC	Ballard Site Concentration [a]		Background Concentration [b]		Diet Targets in Puls (1994) [c]		Mackowiak et al (2004) [d] Chronic Upper Critical Intake	NRC [e] Maximum Tolerable Levels
	Maximum	95% UCL	Maximum	95% UCL	Chronic Toxicity	Acute Toxicity		
Antimony	0.979 [f]	na	5.41	na	--	--	--	70 - 150 [g]
Arsenic	14.2	1.42	na	na	--	--	--	30 [h]
Cadmium	4.54	1.55	1.95	0.461	50 - 500	2,000 - 3,000	50 - 500	10
Chromium	12.3	2.42	na	na	--	--	50 - >1,000	100 [h]
Copper	17.7	6.01	na	na	115 - 500 [i]	na	30 - >100	15 - 250
Molybdenum	425	18.3	8.91	2.09	10 - 203	na	10 - >200	5.0
Nickel	28.7	5.18	na	na	--	--	700 - >1,000	50 - 100
Radium-226	na	na	na	na	--	--	--	--
Selenium	366	39.7	7.28	0.662	> 5.0 - 20.0	> 80	5 - >20	5
Thallium	0.594	0.134	0.0257	0.0113	--	--	--	--
Uranium	0.679	0.125	0.162	na	--	--	--	100 [g]
Vanadium	7.06	0.925	na	na	--	--	--	10 - 50
Zinc	250	59.6	na	na	> 5,000	na	500 - >2,000	300 - 500

Notes

All concentrations are in units of milligrams per kilograms (mg/kg) except for radium-226, which is an activity of picocuries per gram (pCi/g). Measured concentrations and vegetation targets are in dry weight.
Gray highlighting indicates proposed vegetation targets.

-- - source does not list this chemical
95% UCL - 95 percent upper confidence limit on the mean concentration
COC - contaminant of concern
COEC - contaminant of ecological concern
LCOC - livestock contaminant of concern
ROC - radionculide of concern
na - not available

[a] Results of samples collected from culturally significant and nonculturally significant upland vegetation at the Ballard Mine in 2004 and 2009, as reported in the Ballard RI.

[b] Results of samples collected from culturally significant and nonculturally significant upland vegetation at the Ballard Mine in 2009, as reported in the Ballard RI.

[c] Puls, 1994. Mineral Levels in Animal Health. All units in milligrams metal per kilogram diet.

[d] Mackowiak et al (2004). Uptake of selenium and other contaminant elements into plants and implications for grazing animals in southeast Idaho. Ranges are based on a summary of data in Puls (1994); selenium ranges are based on data from additional sources as cited in Mackowiak et al, 2004. Values are based on data from cattle, sheep, goats, and horses, taking in to account susceptibility due to age and the chemical form.

[e] National Research Council, 2005. Mineral Tolerance of Animals.

[f] Not detected; value shown is maximum detection limit.

[g] Value for livestock is not available; values shown are for rodents.

[h] Values for livestock were derived by the NRC (2005) using interspecies extrapolation.

[i] Toxic value is for young calves. Toxic doses in milligram per kilogram body weight are also published.

4 IDENTIFICATION AND INITIAL SCREENING OF REMEDIAL TECHNOLOGIES

This section identifies the GRAs that are specific to each affected medium at the Site, identifies the remedial technologies and associated process options applicable to each media-specific GRA, and screens each technology/process option based on technical implementability. In accordance with the *RI/FS Guidance*, technologies refer to general categories, such as chemical treatment, thermal destruction, immobilization, capping, or dewatering. Process options refer to specific processes within each technology. For example, the chemical treatment technology for the groundwater medium would include process options such as chemical precipitation and oxidation/reduction.

The following paragraphs present the identification and initial screening of the complete range of remedial technologies/process options for each medium (upland soils/waste rock, vegetation, surface water, sediment/riparian soil, and groundwater). The goal of this initial screening is to eliminate those technology types and process options known to have minimal effectiveness for remediation of the Site COCs/ROCs/COECs or are not feasible given the Site conditions (e.g., soil types, depths of contamination, size of the Site, etc.). Technology types and process options also were eliminated if they were not reasonably constructible, or were insufficiently proven.

4.1 REMEDIATION OF SITE VEGETATION

4.1.1 Basis for Remediation

The HHRA included in the BRA identifies unacceptable risks for upland vegetation and riparian vegetation (including aquatic plants; see **Table 2-1**) under two human exposures scenarios; current/future Native American and hypothetical future resident. The unacceptable risks to current/future Native Americans assume a complete exposure pathway by consumption of culturally significant plants. The risk drivers for current/future Native Americans are the detected concentrations of several metals in upland and riparian plant samples, or in the case of aquatic plants, exposure modeled from concentrations of COPCs in sediment. The other unacceptable human health risk is for a hypothetical future resident that ingests fruits and vegetables grown in upland soil that is irrigated with Ballard Site groundwater. The detected concentrations of metals in Site soil and groundwater are the risk drivers for the hypothetical future resident scenario.

The ERA included in the BRA also identified unacceptable risks to a variety of ecological receptors based on exposure to metals in a combination of media including Site vegetation (see **Table 2-2**).

Note that the ERA specifically did not account for potentially higher selenium concentrations that may occur in hyperaccumulator plant species.

4.1.2 Vegetation Types

The vegetation at the Ballard Site is a combination of planted (shrub and trees) and seeded (e.g., alfalfa) vegetation, along with volunteer vegetation from the surrounding area. The vegetation types based on an extensive 2009 investigation are summarized in Section 1.4.2 of this memorandum and are detailed in Appendix A2 of the *P4 Sites RI/FS Work Plan*. Although the 2009 surveys did not extend into the drainages that lead away from the mined areas, it is assumed that the vegetation types in the drainages are similar to the types observed on the mined areas.

Due to the age of the mine, vegetation has developed over most of the mine area with the exception of some mine pit areas, highwalls, and angle-of-repose slopes. The vegetative cover is relatively dense in some areas and primarily consists of grass and forbs species. Other areas with less dense vegetative cover possess a higher percentage of woody species. The vegetation cover at the Site was altered in 2012 by a rangeland fire. The vegetation in portions of the Ballard Site, including parts of MMP035, MWD080, MWD093, and MMP036, were burned.

Culturally Significant Plants. The BRA distinguishes between general plants and culturally significant plants at the Site because consumption of culturally significant plants is a potentially complete exposure pathway for current/future Native Americans. The culturally significant plants that were specifically sampled in the upland areas in 2009 include chokecherry, quaking aspen, rocky mountain juniper, and big/white sagebrush[1]. The composite 2004 vegetation sampling performed in the riparian areas did not segregate culturally significant species from other species. For the riparian areas, the BRA modeled exposures to culturally significant plants using the combined vegetation sample data gathered in the riparian areas along with the COPC/COPEC concentrations in the riparian soil.

4.1.3 Considerations for Evaluating Remedial Alternatives for Vegetation

As discussed above, the unacceptable human health risks identified in the BRA are specific to: 1) current/future Native American consumption of culturally significant plants, and 2) hypothetical

[1] The list of culturally significant plants used during the 2009 vegetation investigation will be compared to the Tribe's current list of culturally significant plants and any differences noted during the FS Process.

future resident ingestion of fruits and vegetables grown in upland soil and irrigated with Site groundwater. To address the risks posed by culturally significant plants, it is not practicable to differentiate between culturally significant plants and non-culturally significant plants (or general plants) when evaluating or selecting remedial alternatives. Culturally significant plants and general plants grow together in both the upland and riparian areas and it would be difficult or impossible to isolate the culturally significant plants for remediation in those areas. Furthermore, the distinction between culturally significant plants and general plants is not relevant to the ecological and livestock risks identified for the Site vegetation. With regards to hypothetical future residents, it would be possible to use institutional controls to prevent the hypothetical exposure scenario. However, evaluation of remedial alternatives for the existing culturally significant plants and the hypothetical future vegetation is addressed with the primary media (e.g., upland soil, sediment) where the plants currently or are expected to grow.

Vegetation is considered a "secondary medium" in that plants uptake COCs/COECs from "primary media" such as soil, sediment, surface water and/or groundwater. As a secondary medium, the vegetation would not trigger risk thresholds that require remediation unless it was growing in a primary media that has sufficient COCs/COECs available for plant uptake. As a result, the selected remedial alternatives to address the primary media also will address the unacceptable risks posed by the vegetation. For example, a remedial alternative that includes construction of a cover system over contaminated waste rock (i.e., capping the primary media) would require that large vegetation (i.e., trees) growing in the waste dumps be removed prior to placing the cap. Similarly, a remedial alternative that includes Monitored Natural Attenuation (MNA), Monitored Natural Recovery (MNR), or ICs for the primary media will have similar effectiveness for the vegetation growing in the primary media. It is generally believed that as these primary media are remediated, the vegetation growing in the primary media would be replaced. However, as discussed in Section 3.5, published vegetation performance targets will be used during the RA to evaluate the effectiveness of the remedial alternative for primary media (i.e., upland soils/waste rock, riparian soils/sediment, surface water and groundwater). In addition, vegetation to be planted to reclaim the surface of any selected cover system would not include plant species that are considered selenium hyperaccumulators.

The remainder of Ballard FS Memo #1 does not include evaluation of vegetation-specific remedial technologies and alternatives. Instead, vegetation is included as a consideration in the remedial alternative evaluations presented for each primary media in the other sections of this FS. The primary-media evaluations consider the effectiveness that the remedial alternatives will have in remediating the vegetation growing in the primary media, and the long-term impacts that the remedial alternative will have on vegetation.

4.2 REMEDIATION OF SITE UPLAND SOILS/WASTE ROCK

This section presents the initial screening of remedial technologies/process options that are applicable to the upland soils/waste rock at the Ballard Site (see **Drawing 2-1**). The waste rock is considered a source material for contaminants (COCs/ROCs/COECs) detected in other media at the Site. The waste rock deposition areas (i.e., the waste rock dumps) also contain some sediments, riparian soils, and vegetation, but remedial activities associated with the waste rock also will address concerns with those media as further described in Sections 4.3 and 4.4. This section then deals specifically with only upland soils and waste rock found in mine waste rock dumps throughout the Site. On the Ballard Site, seasonal ponds exist within the waste rock areas. These ponds, which form in depressions in the waste rock mined, will be addressed by the RAs associated with the waste rock. For example, regrading to promote storm water flow will by default remove the depressions containing the ponds.

4.2.1 Basis for Remediation

As presented in Section 2.1, upland soils at the Site have been impacted by historical mining activities. The primary source for contamination at the Ballard Site is the waste rock that has been placed in the various waste rock dumps and partially backfilled mine pits throughout the Ballard Site. The human health risk assessment included in the BRA concluded that the cancer and non-cancer risks posed to current/future receptors by direct exposure to COCs in upland soil <u>fall</u> <u>within</u> the acceptable risk range. However, the BRA concluded that there are unacceptable risks associated with hypothetical future use conditions and potential current/future Native American consumption of plants that grow in the Site upland soil (see **Table 2-1**). Unacceptable risks also were associated with direct exposure to ROCs in upland soil for all receptors except the camper/hiker in a health-protective Tier I (i.e., based on maximum detected Site concentrations rather than incremental risk above background) risk evaluation (**Table 2-2**).

The ecological risk assessment included in the BRA also identified unacceptable risks to a variety of ecological receptors based on exposure to metals in upland soil and other media at the Site (see

Table 2-2). The livestock risk assessment included in the BRA also identified unacceptable risks to livestock grazing in the Ballard Site area due to selenium concentrations (see **Table 2-3**). The COCs/COECs that contribute to unacceptable risk, as shown in **Table 2-7**, are antimony, arsenic, cadmium, chromium, copper, molybdenum, nickel, selenium, thallium, uranium, vanadium, and zinc.

As discussed in more detail in Section 4.1, vegetation is considered a "secondary medium" for the purposes of evaluating remedial technologies because plants uptake COCs/COECs from "primary media" such as upland soil. As a secondary medium, the vegetation would not trigger risk thresholds that require remediation unless it was growing in a primary media that has sufficient COCs/COECs available for plant uptake. The remedial technologies selected to address unacceptable risks posed by the primary media also will address the unacceptable risks posed by the vegetation. As such, vegetation also is included as a consideration in the overall effectiveness of the evaluation of remedial technologies and subsequent remedial alternatives presented for upland soils/waste rock and performance targets for vegetation are further discussed in Section 3.5.

4.2.2 Volumes and Areas of Impacted Soils/Waste Rock

Engineering estimates of the total volume of fill present at each of the open mine pits and waste rock dumps have been developed based on review of RI data and available aerial images of facility topography prior to mine development and after cessation of mining. These volume and area estimates are presented in **Table 4-1** and compare very well with material volumes in the mine records. **Drawing 4-1** shows the waste rock dumps and their surface expression along with their associated pits.

The areas and volumes presented in **Table 4-1** and topographic/spatial relationships depicted on **Drawing 4-1** are important screening criteria for evaluating soil remedial technologies (e.g., excavating, regrading, capping, and/or treatment of these fill materials) and directly relate to technical implementability. For example, the Site upland soil and waste rock analytical data indicate elevated concentrations of Site COCs/ROCs/COECs are limited to the physical boundaries of the waste rock dumps with very little to no migration to the surrounding soils. Therefore, regrading and some type of cover system for the waste rock would be the primary technologies and process options to consider for the Site.

As the Site proceeds through the FS process, there may be a need to group the various mine pits and waste rock dumps into remediation areas (RAs). By segregating the mine pits and waste rock dumps, it may become more efficient to evaluate different remedial technologies and alternatives depending on individual RA conditions and select the appropriate alternative for cleanup for individual RAs.

4.2.3 General Response Actions Applicable to Upland Soils/Waste Rock

Six general categories of RAs, or GRAs, are applicable to the upland soils and waste rock at the Site including:

- **No-Action** – the NCP requires that the no-action response be considered and carried through detailed analysis to serve as a baseline for comparison in the evaluation of the other five general categories of RAs.
- **Limited Action** – represents a response action that uses Institutional Controls (ICs, e.g., restrictive covenants) and Land Use Controls (LUCs, e.g., fencing) to limit human exposure to contaminated media through administrative and engineering controls.
- **Containment** – includes capping and/or construction of barriers to limit direct contact with and minimize mobility of COCs/ROCs/COECs.
- **Removal and Disposal** – includes excavation of materials that contain COCs/ ROCs/COECs followed by on-site or off-site disposal.
- **Ex-Situ Treatment** – includes excavation of site soils followed by treatment to reduce mobility, toxicity, or volume of COCs/ ROCs/COECs.
- **In-Situ Treatment** – includes treatment of soil in-place to reduce mobility, toxicity, or volume of COCs/ ROCs/COECs.

The technologies and process options that potentially are applicable to the GRAs for the upland soils and waste rock at the Site are identified and screened based on technical implementability below.

4.2.4 Potentially Applicable Upland Soil/Waste Rock Technologies

Applicable technologies (and associated process options) considered for remediation of the upland soil/waste rock COCs/ROCs/COECs (other than No-Action) are listed below and organized by the GRAs. A detailed description of these technologies/process options and the initial screening, including the rationale for selection or rejection, is summarized in **Table 4-2**. The final column in this table identifies if technologies/process options are retained for additional screening or are screened out.

4.2.4.1 Limited Action Response

The Limited Response Action technologies considered for upland soil/waste rock are described in more detail and screened in **Table 4-2,** and include ICs (e.g., government controls, proprietary controls, enforcement tools, and informational tools) and LUCs (e.g., fencing, signage, and other physical barriers).

4.2.4.2 Containment

Containment technologies prevent direct contact with COCs/ ROCs/COECs, reduce or eliminate infiltration of precipitation, and/or to prevent uptake of COCs/ ROCs/COECs by vegetation. Containment does not reduce the volume or toxicity of COCs/ ROCs/COECs. Containment can be achieved via cover systems, vertical barriers, and site controls. The containment technologies and process options potentially applicable to the COCs/ ROCs/COECs are listed below. Screening details are provided in **Table 4-2**.

Capping. Capping involves covering impacted areas with soil covers to prevent direct contact with COCs/ ROCs/COECs and minimize the infiltration of precipitation, thereby reducing the migration of COCs/ ROCs/COECs to air, soils, and groundwater. Capping also can prevent uptake of COCs/ ROCs/COECs by vegetation. Capping has been proven to be readily implementable at various sites and is effective at isolating COCs/ ROCs/COECs from the environment with minimal long-term maintenance. The following capping options are considered for preliminary screening:

- Multi-Layered Cap
- Asphalt/Concrete Cap
- Evapotranspirative (ET) Cap
- Soil Cover Cap

Vertical Barriers. Vertical barriers are used in soil to restrict the lateral migration of COCs/ ROCs/COECs in Site soils and include the construction of sheet pile or grout walls to prevent lateral migration of COCs/ ROCs/COECs through soils away from areas of concern (i.e., a source area).

Surface Controls. Infiltration of precipitation may be reduced by directing surface runoff away from areas of concern and re-vegetating impacted areas. Surface controls consist of the following two options:

- Soil Grading
- Revegetation

4.2.4.3 Removal, Disposal, and/or Reuse

Removal and disposal of impacted upland soils and waste rock material is a proven technology to reduce or eliminate onsite risks posed by COCs/ ROCs/COECs. By removing these materials and disposing them in appropriate locations, the COCs/ ROCs/COECs are no longer present to impact site soils, groundwater, and vegetation. The removal and disposal technologies and process options potentially applicable to the COCs/ ROCs/COECs in the Site upland soils/mine waste are listed below and are screened in **Table 4-2**.

Removal

- Conventional Excavation - involves the use of excavation equipment such as backhoes, trackhoes, scrapers, front-end loaders, and/or bulldozers to dig, scrape or push materials which require treatment, relocation, or contouring.

Disposal

- Consolidation and On-Site Disposal/Backfilling - involves excavation of impacted upland soil/waste rock followed by transport and placement elsewhere on Site.
- Off-Site Disposal – involves excavation of waste rock and/or impacted upland soils followed by transport and disposal off-site.

4.2.4.4 Ex-Situ Treatment

Ex-situ physical, chemical, thermal, or biological treatment technologies could be used to treat impacted soil and waste rock following excavation to reduce the volume or toxicity of COCs/ ROCs/COECs. The ex-situ processes that were considered are listed below. All of these ex-situ treatment technologies are <u>eliminated</u> from further consideration at the Site based on the rationale presented in **Table 4-2**.

- **Physical Treatment** - includes technologies such as stabilization and aeration to reduce the mobility or toxicity of COCs/ ROCs/COECs. The process options evaluated include:
  - ✓ Stabilization/Solidification (S/S)

- ✓ Dewatering
- ✓ Separation

- **Chemical Treatment** – involves addition of chemicals that convert COCs/ ROCs/COECs into less hazardous compounds. The process options evaluated include:
  - ✓ Soil Washing
  - ✓ Chemical Oxidation
  - ✓ Chemical Extraction
- **Thermal Treatment –** generally involves the destruction or removal of contaminants through exposure to high temperature in treatment cells, combustion chambers, or other means to contain the contaminated media during the remediation process. The thermal treatment processes involve the application of energy in the form of heat to separate, destroy, or immobilize contaminants. The process options evaluated include:
  - ✓ Incineration
  - ✓ Thermal Desorption
- **Biological Treatment** – consists of enhancing the biological degradation of organic constituents by microorganisms.

4.2.4.5 In-Situ Treatment

In-situ or in-place treatment would treat impacted upland soil and waste rock material in place using physical, chemical, thermal, and biological processes to reduce the volume or toxicity of COCs/ ROCs/COECs. Because in-situ treatment would not require excavating the material, it generally is considered safer to implement than ex-situ technologies. However, it may be difficult for in-situ technologies to completely treat the constituents detected in Site soils/waste rock in-place because of their heterogeneous nature. The following in-situ treatment options were considered for treatment of soils containing radionuclides and metals. However, as a whole, in-situ treatment process options do not appear to be viable treatment processes because of the aerial distribution and volume of the upland soils and waste rock found at the Site. As a result, all of the in-situ treatment technologies listed below have been eliminated from further consideration as discussed in **Table 4-2**.

- **Physical Treatment -** includes technologies such as stabilization and aeration to reduce the mobility or toxicity of COCs/ ROCs/COECs. The process options evaluated include:

- ✓ Stabilization/Solidification (S/S)
- ✓ Soil Vapor Extraction (SVE)

- **Chemical Treatment -** chemical additives are mixed in-situ with contaminated soils to initiate chemical reactions that convert COCs/ ROCs/COECs into less hazardous compounds.
- **Thermal Treatment -** involves the application of energy in the form of heat to: catalyze the COCs/ ROCs/COECs to immobilize or detoxify inorganic compounds, or destroy them and generate nontoxic constituents (e.g., water, carbon dioxide). The process options evaluated include:
  - ✓ Vitrification
  - ✓ In-Situ Thermal Desorption (ISTD)
- **Biological Treatment -** consists of enhancing the existing biological degradation of organic constituents by microorganisms.

4.3 REMEDIATION OF SITE SURFACE WATER

This section presents the initial screening of remedial technologies/process options that are applicable to the contaminated surface water present at the Ballard Site. Impacted surface water includes: 1) seeps/springs that discharge along the margins of the disturbed mine areas, 2) mine dump seeps within the mined area that do not discharge off the Site, but contribute to groundwater contamination, and 3) the surface water periodically present in the ephemeral/intermittent streams that lead away from the disturbed mine areas. The surface water that is periodically present in the seasonal ponds located within the disturbed mine areas are not included in this section because those areas will be addressed through RAs associated with upland soils/waste rock (i.e., storm water run-on/run-off control). Additional information regarding the surface water hydrology at the Ballard Site is located in Section 2.4 of the *Ballard Mine RI Report.*

4.3.1 Basis for Remediation

Site impacts to surface water are dominated by elevated levels of selenium, which is the primary ecological risk driver in surface water. However, because of the ephemeral/intermittent flows, the streams leading away from the Site have poor quality aquatic habitat incapable of supporting fish populations. Contaminant loading to the Blackfoot River is the most significant aquatic ecological concern because it is the only perennial surface water body that has receptors downstream of the Site. Arsenic also is a human health risk driver for surface water; however, this risk largely is associated with arsenic detected in seeps located at the toe of waste rock dumps. The COCs/COECs that drive risk in surface water are summarized in **Table 2-7**.

Surface water quality cleanup levels presented in **Table 3-6** are exceeded in Site surface waters for a relatively large number of analytes including: selenium and cadmium that exceed the proposed cleanup levels, with isolated cleanup level exceedances of aluminum, arsenic, copper, and manganese (refer to Section 3.5). Surface water samples collected from dump seeps and springs adjacent to the source areas contain a greater number of constituents elevated above their respective cleanup levels and at higher concentrations when compared to stream samples collected from downstream sources.

The RAs for the surface waters of the Site, therefore, have to consider a broad range of inorganic analytes with varying chemical constituents. However, with the exception of selenium, the mobility of the other surface water COC/COECs is relatively low and the areas of concern are generally proximal to the Site sources.

4.3.2 Volumes and Areas of Impacted Surface Water

All of the stream courses emanating from the Ballard Site are ephemeral/intermittent, and thus, do not contribute to downstream contaminant loading during baseflow conditions, which is the case for approximately nine months of the year. Drainages fed by perennial seeps and springs dry up through evaporation and infiltration within about 100 feet of the source during baseflow months. **Table 4-3** provides the runoff and baseflow discharges for the monitored streams on the east and west sides of the Site: Wooley Valley Creek and Ballard Creek, respectively (see **Drawing 2-5** for locations). The screening of remedial technologies/process options for surface water does not consider Long Valley Creek because the Ballard Site contributes very little flow to this drainage, and monitoring locations with measureable flow to the drainage have not been identified on Ballard Site. Runoff and storm water contribution to the Blackfoot River from the Site is seasonal and largely immeasurable given the much higher flows in the river (see Section 5.4.2 of the *Ballard Mine RI Report*).

Surface water sources at the Site that feed off-Site stream flows are intermittent/seasonal storm water and snowmelt runoff and perennial spring and seep discharges. Runoff at the site is generally diffuse with very few defined overland runoff channels. Much of the runoff reaches the off-Site channels as interflow in the waste rock and adjacent soils. Most of the contaminant loading to the drainages originates from the mine dump seeps and associated springs, which discharge at higher flows during the snowmelt and runoff periods. The majority of these features are located on the southern portions of the Site (MSG004 – MSG007, MST095, MST096, MSG008, MST069 and MST067 - **Drawing 2-5**). The springs are primarily mine dump seepage or are impacted by dump seepage, but do not discharge directly from the toe of a mine waste rock dump. Stations MST067, MST069, MST095 and MST096 are classified as stream stations, but are fed directly by dump seepage. Flow from these discharges range from approximately 90 gpm (0.2 cfs) to 4.5 gpm (0.01 cfs) during snowmelt, to 4.5 gpm to dry during the baseflow period (see Section 5.1.6.1 of the *Ballard Mine RI Report*).

Four mine dump seeps and a spring within the mined area do not discharge off the Site, but are considered in the technology screening. These seeps and spring (MDS030 – MDS033 and MSG003) are located on the hill above the West Ballard Mine Pit (MMP035 - **Drawing 2-5**). These seeps/springs discharge to the mine pit where the impacted seepage-derived surface water infiltrates to the groundwater system. Five small seasonal ponds are located within the mining disturbed area. These ponds primarily form in depressions in the mine pit floors, aside from MSP013, which was constructed to contain sediment. The Site ponds are all less than a quarter acre in size and none are perennial. Pond MSP010 was the only pond located at the periphery of the site. MSP010 was closed through an interim action in 2010. All of the other ponds are located in the mine-disturbed or waste rock areas and will be addressed by RAs completed in those areas. As an example, regrading and capping to create positive drainage are described in Section 4.2. A major objective of these activities will be the elimination of all standing-water areas except those specifically designed to contain non-contact (clean) storm water.

4.3.3 General Response Actions Applicable to Surface Water

Based on a review of the data collected during the RI and the established RAOs, six general categories of GRAs were identified for Site surface water including:

- **No-Action** – represents a "base case" for comparison in the evaluation of the other five general categories of RA.
- **Limited Action Response** – includes such actions as routine surface water monitoring, deed restrictions, and surface water use restrictions.
- **Source Controls** – includes actions to remove or control (contain) historic or potential sources of site-related constituent migration to surface water.
- **Containment** – includes construction of features to retain surface water on the Site.

- **Removal and Disposal** – consists of surface water collection and either recycling for beneficial reuse, disposal by surface discharge (e.g., retention/evaporation pond), or disposal by underground injection.

- **Ex-Situ Treatment** – consists of physical, chemical, thermal, electrolytic, or biological treatment of collected surface water prior to recycling or disposal.

- **In-Situ Treatment** – injection of chemical agents or air to neutralize, precipitate, or destroy the COCs in Site surface water.

The technologies and process options that potentially are applicable to the GRAs for Site surface water are identified and screened in the following section.

4.3.4 Potentially Applicable Surface Water Technologies

Applicable technologies and associated process options considered for remediation of the surface water COCs/COECs (other than No-Action) are listed below and organized by the GRAs. The initial screening of these technologies/process options are described in more detail and screened in **Table 4-4**. The final column in this table identifies those technologies/process options that are retained for further screening in Section 5.0 or have been screened out (rejected).

4.3.4.1 Limited Action Response

The Limited Response Action technologies considered for Site surface water are described in more detail and screened in **Table 4-4**, and include:

- Institutional Controls (ICs)

- Land-Use Controls (LUCs)

4.3.4.2 Source Controls

Source controls include actions that reduce or eliminate constituent migration from known and potential source areas to surface water. The primary COC/ROC/COEC sources at the Site are the mine waste rock dumps. Precipitation falls on the source material and runs off or infiltrates into the waste rock, and both actions can mobilize contaminants. Uncontaminated storm water may also flow onto source material and either infiltrate or runoff, mobilizing contaminants. The contaminated water either travels overland and combines with other storm water flows until it discharges from the Site, or infiltrates and discharges to seeps/springs near the edges of the mine waste rock dumps. Contaminated ponds on the Site largely result from the capture of contaminated surface water runoff, or possibly shallow interflow in the mine dumps. Therefore, the primary source controls for the Site surface water focuses on limiting water contact with the waste rock. Actions that would result in source controls are discussed as part of the evaluation of remedial technologies for upland soil/waste rock in Section 4.2 and are not repeated herein.

4.3.4.3 Containment

Surface water containment can include collection and containment in tanks or reservoirs. Although perpetual storage of water without discharge is not possible, temporary containment could be a component of the larger Site remedy. The second possible function of containment is to contain and reduce suspended concentrations of contaminants in surface water. Process options evaluated include:

- Retention Basins
- Wetlands

4.3.4.4 Removal and Disposal

Removal. Removal of surface water is accomplished by collection and isolation in a pond or tank, typically for storage, treatment, or disposal. Alternatively, a removal action could be eliminating the water discharging from the waste rock to the surface water channels.

Disposal. The disposal technologies and the disposal process options potentially applicable to the COCs/COECs in the Site surface water include:

- Recycle/Reuse
- Land Application
- Treated Surface Water Discharge
- Evaporation/Infiltration
- Publically Owned Treatment Works (POTW)
- Injection Wells

The removal and disposal technologies and process options potentially applicable to the COCs/COECs in the Site surface water are described and the results of the initial screening are presented in **Table 4-4**.

4.3.4.5 Ex-Situ Treatment

Ex-situ (active treatment) technologies would be performed to treat collected surface water to acceptable levels. These treatment technologies are evaluated for their ability to reduce the concentrations of selenium and other contaminants that exceed the chemical-specific cleanup levels for the receiving water or application location (i.e., discharge to surface waters vs. groundwater). The ex-situ treatment technologies and process options potentially applicable to the COCs/COECs in the Site surface water are described in detail and screened in **Table 4-4**. The ex-situ treatment technologies considered include:

- **Physical Treatment** – primarily separates or replaces the elements or compounds from the water being treated. Process options evaluated include:
  - ✓ Solid/Water Separation
  - ✓ Filtration
  - ✓ Adsorption
  - ✓ Ion Exchange
  - ✓ Membrane Technologies
- **Chemical Treatment** – involves processes where the COCs/COECs are altered into a less toxic form or precipitated from solution. Many of the COCs/COECs in Site surface water occur as oxyanions (e.g., arsenic and selenium), which rely on transformation to more reduced (less mobile) forms of the element. Other COCs/COECs are cationic polyvalent metals (e.g., cadmium and copper), which can be chemically treated by precipitation/co-precipitation, reduction, or sorption. Process options evaluated include:
  - ✓ Solvent Extraction
  - ✓ Chemical Precipitation
  - ✓ Oxidation/Reduction
- **Thermal Treatment** – involves the application of energy in the form of heat to catalyze and immobilize or detoxify the COCs/COECs, or to destroy them through generation of non-toxic constituents (e.g., water and carbon dioxide). Process options evaluated include:
  - ✓ Evaporation/Distillation
  - ✓ Wet Air Oxidation

- **Biological Treatment** – involves the transformation, degradation, or fixation of contaminants by microorganisms.

4.3.4.6 In-Situ Treatment

In-situ treatment technologies are designed to treat contaminated surface water without extracting the water. The in-situ treatment technologies and process options potentially applicable to the COCs/COECs in the Site surface water include:

- **Physical Treatment** – primarily separates or replaces the elements or compounds from the water being treated. The process option evaluated includes:
  - ✓ Mechanical Aeration
- **Chemical Treatment** – involves processes where the COCs/COECs are altered into a less toxic form or precipitated from solution. Many of the COCs/COECs in Site surface water occur as oxyanions (e.g., arsenic and selenium), which rely on transformation to more reduced (less mobile) forms of the element. Other COCs/COECs are cationic polyvalent metals (e.g., cadmium and copper), which can be chemically treated by precipitation/co-precipitation, reduction, or sorption. Process options evaluated include:
  - ✓ Chemical Injection (Oxidation/Reduction/Hydrolysis)
  - ✓ Permeable Reactive Barrier (PRB)/Chemical Injected Reductive Reaction Zone
- **Thermal Treatment** – involves the application of energy in the form of heat to catalyze the COCs/COECs, to immobilize or detoxify inorganic compounds, or to destroy those generating non-toxic constituents (e.g., water and carbon dioxide). The process option evaluated includes:
  - ✓ In-Situ Thermal Desorption
- **Biological Treatment** – involves the transformation, degradation, or fixation of contaminants by microorganisms.

4.4 REMEDIATION OF SITE SEDIMENT AND RIPARIAN SOIL

This section presents the initial screening of remedial technologies/process options that are applicable to the contaminated sediment and riparian soil present in and along the intermittent streams that lead away from the disturbed mine areas. These streams include Wooley Valley Creek and Ballard Creek, and their tributaries. The screening of remedial technologies/process options does not consider Long Valley Creek because detected concentrations of COCs/COECs generally do not exceed screening levels in that drainage. The sediments in ponds within the mining areas are addressed along with upland soil/waste rock (see Section 4.2) and are not included here.

The evaluation of remedial alternatives for sediment and riparian soil are combined in this FS because sediment and riparian soil at the Site are adjacent and contiguous and the candidate remedial alternatives for sediment and riparian soil are similar.

4.4.1 Basis for Remediation

Sediment. The human health risk assessment included in the BRA concluded that direct exposure to contaminants in sediment is potentially a complete exposure pathway, but is <u>insignificant</u> for the human health receptors evaluated. Indirect human exposure through consumption of organisms that uptake contaminants is an incomplete pathway because surface water bodies in the Ballard Site area do not support fish. As such, the BRA did not quantify direct exposure human health risks posed by Site sediment. However, the BRA concluded that there are unacceptable risks associated with current/future Native American consumption of culturally significant aquatic plants that grow in the Site sediment and unacceptable risks to ecological receptors. The COCs/COECs that contribute to unacceptable human health and ecological risks in sediment, as shown in **Table 2-7**, are antimony, arsenic, cadmium, copper, molybdenum, selenium, thallium, and vanadium.

Riparian Soil. The human health risk assessment included in the BRA concludes that the incremental cancer risks posed to current/future Native Americans by direct exposure to riparian soil falls within the acceptable risk range. However, the BRA concludes that there are unacceptable risks associated with current/future Native American consumption of culturally significant plants that grow in the Site riparian soil and unacceptable risks to ecological receptors.

The human health exposure to plants growing in riparian soil were calculated using plant tissue data, where available, or modeled from riparian soil concentrations for COPCs not directly analyzed in plant tissue samples. The COCs/COECs that contribute to unacceptable risk, as shown in **Table 2-7**, are arsenic, cadmium, chromium, copper, molybdenum, nickel, selenium, thallium, and vanadium.

Vegetation Considerations. As discussed in Section 4.1.3, the unacceptable human health risks to site vegetation are addressed in this Ballard FS Memo #1 through evaluation of remedial alternatives for the primary media where the affected vegetation is growing. Accordingly, the remedial alternatives evaluated below for sediment and riparian soil consider the effectiveness of each remedial alternative on vegetation found in the identified intermittent stream corridors.

Drainage Morphology Considerations. For the purposes of screening remedial alternatives, it is important to note that Wooley Valley Creek, Ballard Creek, and their tributaries are intermittent streams that only flow during the wetter spring months, primarily during spring runoff. These streams normally are dry along their entire reach during the summer and fall. The morphology of these drainages generally is shallow and narrow grass-lined depressions or swales in the steeper headwater areas (e.g., near the Ballard Mine pits/waste rock dumps) that become slightly deeper and wider toward the valley floor. Some of the lower reaches of Wooley Valley Creek have a defined channel; however, the upland reaches do not have clearly defined stream channels other than the minor swales/coulees.

These intermittent stream reaches near the Site, especially in the headwater areas, do not have large sediment deposits (e.g., point bars) that are more typical of perennial streams. Instead, the sediment deposits in the intermittent drainages near the Site are relatively minor and often are indistinguishable from the adjacent soil. This is particularly true in the headwater areas where the drainages are small and indistinct. These headwater areas also are where the COC/COEC concentrations are highest in the sediment/riparian soil due to their proximity to the sources of COCs/COECs in the mined area.

Sediment in these intermittent drainages comes from not only the Site, which is located high in the drainages, but other highlands areas nearby which are unaffected by the Site, but are expected to contribute sediment to these identified streams lower in their courses (see **Drawing 1-4**). These physical characteristics of the intermittent streams are considered when screening remedial technologies discussed below.

4.4.2 Volumes and Areas of Impacted Sediment and Riparian Soil

Based on data collected during the RI, the following conservative assumptions regarding the areas and volumes of sediment/riparian soil that require remediation for the purposes of screening remedial alternatives are made:

- The depth of both sediment and riparian soil potentially requiring remediation is conservatively assumed to average 12 inches below grade, which is 3-times the depth that the sediment samples were collected during the RI and 2-times the depth that riparian soil samples were collected during the RI. It is assumed that Site COCs/COECs eroded from upland areas and deposited in the sediment/riparian soil would be limited to this 12-inch depth.
- The width or corridor along the streams where the sediment/riparian soil require remediation is assumed to average 30 feet, or 15 feet to either side of the center line of the stream channel. Based on the stream-sampling location photographs included in Appendix

C of the *Ballard Mine RI Report*, this assumption may underestimate or overestimate the impacted corridor depending on the variable stream morphology along the reach of each stream. For example, a 30-foot corridor may underestimate the width of impacted sediment/riparian soil in topographically flat areas where the stream channel is not distinct and likely meanders across a larger area. Alternatively, a 30-foot corridor may overestimate the width of impacted sediment/riparian soil in topographically steeper areas where there is a distinct stream channel with narrow riparian banks. The 30-foot average width is considered a representative assumption that accommodates the observed morphologies of the impacted Site streams.

- For Ballard Creek and its impacted tributary, the length of the stream/tributary corridors where sediment/riparian soil require remediation is assumed to be from the headwaters of the stream/tributary near the edge of the mining disturbed area (i.e., near sampling locations MST067 and MST068) to where the Ballard Creek discharges into the Blackfoot River. This length may be revised based on changes to remediation levels presented earlier in this document (see Section 2.3).

- For Wooley Valley Creek and its tributaries, the length of the stream/tributary corridors where sediment/riparian soil require remediation is assumed to be from the headwaters of the stream/tributaries near the edge of the mining disturbed area (i.e., near sampling locations MST094, MST095, and MSG005) to downstream monitoring location MST272. This length may be revised based on changes to remediation levels presented earlier in this document (see Section 2.3).

Using the above assumptions, the resulting volume of sediment/riparian soil requiring remediation in the Ballard Creek drainage and its impacted tributary is 20,513 cubic yards (cy). The resulting volume of sediment/riparian soil requiring remediation in the Wooley Creek drainage and its impacted tributaries is 57,720 cy. The area and volume assumptions listed above using PCLs will be refined in the RD after the Site-specific cleanup levels are approved in the ROD.

4.4.3 General Response Actions Applicable to Sediment/Riparian Soil

Five general categories of GRAs are applicable to Site sediment/riparian soil including:

- **No-Action** – represents a "base case" for comparison in the evaluation of the other four general categories of RA.

- **Limited Action Response** – represents a response action that uses ICs (e.g., restrictive covenants) and LUCs (e.g., fencing) to limit human exposure to contaminated media through administrative and engineering controls. Monitoring Natural Recovery (MNR) is limited action response that allows natural processes to reduce the mass, toxicity, mobility, volume or concentration of contaminants while conducting periodic monitoring to evaluate performance.

- **Containment** – includes capping and/or construction of barriers to limit direct contact with and to minimize mobility of COCs/COECs.

- **Removal and Disposal** – excavation of materials that contain COCs/COECs followed by on- or off-site disposal.

- **Ex-Situ and In-Situ Treatment** – various techniques that can be implemented either in-situ or ex-situ to reduce mobility, toxicity, or volume of COCs/COECs.

4.4.4 Potentially Applicable Sediment/Riparian Soil Technologies

Applicable technologies and associated process options considered for remediation of the sediment/riparian soil COCs/COECs (other than No-Action) are briefly discussed below and organized by the GRAs. These technologies/process options are described in more detail and screened in **Table 4-5**. The final column in this table identifies those technologies/process options that are retained for further screening and those that have been screened out (rejected).

4.4.4.1 Limited Action Response

The Limited Response Action technologies considered for Site sediment/riparian soil include:

- Institutional Controls (ICs) and Land-Use Controls (LUCs)

- Monitored Natural Recovery (MNR)

4.4.4.2 Containment

The containment GRA includes capping and/or construction of barriers to limit direct contact with and to minimize mobility of COCs/COECs. The containment technologies considered for sediment/riparian soil include:

- Cover Systems (various caps)

- Channelization

4.4.4.3 Removal and Disposal

Removal. Removal and subsequent disposal of impacted sediment/riparian soil is a proven technology to reduce or eliminate risks posed by COCs/COECs. By removing these materials and disposing them in appropriate locations, the COCs/COECs are no longer present to impact culturally significant plants or ecological receptors.

The removal process options considered for the contaminated sediment/riparian soil include:

- Sediment Traps/Basins

- Conventional Excavation

- Suction Dredging/Hydraulic Pumping

Disposal. Disposal of the excavated sediment/riparian soil includes the following options:

- Consolidation and On-Site Disposal
- Off-Site Disposal

4.4.4.4 In-Situ/Ex-Situ Treatment

The in-situ or ex-situ treatment technologies that are suitable to the Site COCs/COECs in sediment/riparian soil include:

- **Physical Treatment** – includes technologies such as stabilization to reduce the mobility or toxicity of COCs/COECs. The process options evaluated include:
  - ✓ Solidification/stabilization
  - ✓ Vitrification
- **Chemical Treatment** – chemical additives that convert chemicals into less hazardous compounds. The process option evaluated includes:
  - ✓ Soil washing (chemical extraction)
- **Biological Treatment** – consists of uptake of COC/COECs by plants during phytoremediation.

Treatment technologies that are not effective for inorganic constituents are not considered (e.g., thermal treatment).

4.5 REMEDIATION OF SITE GROUNDWATER

4.5.1 Basis for Remediation

Site groundwater impacts are dominated by human health risks associated with elevated concentrations of selenium in the shallow alluvial groundwater systems. There are isolated occurrences of elevated concentrations of arsenic that result in arsenic also being a risk driver. However, the occurrences of arsenic above its MCL of 0.01 mg/L are limited temporally and spatially, and may be associated, in part, with background. The selenium concentrations of concern are widespread and clearly are associated with Site sources (i.e., mine waste rock dumps). Selenium concentrations in groundwater above the relevant ARARs defines the limit of Site-impacted groundwater for the purpose of evaluating possible groundwater RAs in the FS.

While not identified as risk drivers in the BRA, cadmium (MCL of 0.005 mg/L), is detected above the groundwater MCL. Exceedances occur sporadically, but are coincident in the areas of selenium contamination. Therefore, the technologies and process options in this section are screened based the overall selenium groundwater contaminant areas or plumes, but cadmium reduction is also considered.

4.5.2 Impacted Hydrogeology

As discussed in Section 1.4.6 and Section 2.1.5, the groundwater system at the Site can be divided into (1) local shallow groundwater systems within basin-fill alluvium, (2) shallow to deep intermediate systems within sedimentary bedrock units, and (3) regional groundwater flow systems within deeper sedimentary bedrock units. The *Ballard Mine RI Report* identified locations where two of the groundwater systems were affected by COCs above ARARs (the proposed cleanup levels in **Table 3-6**): the alluvial system on the east and west sides of the Site (see **Drawings 2-7** and **2-8**), and the regional Wells Formation system beneath and adjacent to the West Ballard Mine pit (MMP035; see **Drawing 2-6**). Sections 4.5, 5.1.4 and 5.4.4 of the *Ballard Mine RI Report* provide extensive information of the nature and extent of contamination and the fate and transport of COCs in the groundwater.

The extent of the affected alluvial groundwater was characterized primarily by an extensive direct-push groundwater study along with monitoring well installation and sampling. The groundwater plumes that were defined are shown on **Drawings 2-7** and **2-8**. Six plumes have been identified and are indicated by their origin (MWD084, MWD082 North, MWD082 South, MWD080 North, MWD081 South, and MWD080/081 Central). The plumes originating from MWD081 South and MWD080/081 Central flow to the Blackfoot River (**Drawing 2-8**). Up and downgradient monitoring does not detect appreciable changes in selenium concentration, which may indicate contribution is minor compared to the total river flow. None of the other plumes have reached a potential discharge location. The depth to first groundwater in the alluvial system typically ranges from a foot below the ground surface (bgs) to 15 feet bgs and rarely as deep as 20 feet bgs. The groundwater in the alluvial system is contained in alternating sand, clay and silt beds with rare gravel beds of colluvial and alluvial origin. Beds are typically thin, being a foot or less thick but they can be highly variable. Groundwater is best characterized as being unconfined to semi-confined between clay beds. Hydraulic testing of alluvial wells indicates that the average hydraulic conductivity of the water bearing portions of the unit is on the order of 10^{-4} cm/sec and groundwater flow velocities were estimated as ranging from 17 to 109 feet/year at the Site.

The hydrogeologic setting of the Wells Formation system is markedly different than the alluvial system. Groundwater is contained in the Pennsylvanian Wells Formation, which is dominated by sand and limestone beds of feet to tens of feet thick. Water-bearing beds have hydraulic conductivities on the order of 10^{-3} to 10^{-2} cm/sec. These beds can produce significant groundwater. However, the poorly cemented sandstone of the unit causes difficulties when drilling, installing, and producing water from the wells. Within the Site, the bedrock units are folded and faulted resulting in compartmentalization and complex groundwater flow systems. The depth to groundwater in the Wells Formation at the Site ranges between 200 and 400 feet bgs in the area of the West Ballard Mine Pit (MMP035), and between 100 to 200 feet bgs in the other perimeter areas.

The Wells Formation was found to contain elevated concentrations of COCs around the West Ballard Mine Pit. Monitoring wells MMW001, MMW006, and MMW020 have COC concentrations above chemical-specific ARARs (see **Drawing 2-6** for locations). Monitoring well MMW021 on the west side of the pit has elevated COC concentrations, but does not exceed chemical-specific cleanup levels. Other Wells Formation monitoring wells (MMW030 and MMW031) at the perimeter of the Site were found to contain background concentrations of COCs. The source of the COCs at the West Ballard Mine Pit appears to be dump seeps and a spring that flows down the east pit wall before infiltrating into the exposed Wells Formation in the bottom of the pit. The rapid response of water levels and selenium concentrations to spring runoff in monitoring well MMW020 support this conclusion. The regional groundwater flow in the Wells Formation is to the northwest, but because of the complex hydrogeologic conditions of the Site, a specific flow field has not been defined and is locally complex because of the folding and faulting.

4.5.3 General Response Actions Applicable to Groundwater

Seven categories of GRAs are applicable to groundwater. These are:

- **No-Action** – represents a "base case" for comparison in the evaluation of the other six general categories of RAs.
- **Limited Action Response** – includes such actions as routine groundwater monitoring, deed restrictions, and groundwater extraction/use restrictions.
- **Source Controls** – includes actions to remove or control (contain) historic or potential sources of site-related constituent migration to groundwater.

- **Containment** – includes construction of subsurface barriers to control lateral flow direction of groundwater.
- **Removal and Disposal** – consists of groundwater pumping and either recycling for beneficial reuse or disposal by surface discharge or injection.
- **Ex-Situ Treatment** – consists of physical, chemical, thermal, or electrolytic treatment of extracted groundwater prior to recycling or disposal.
- **In-Situ Treatment** – consists of injection of chemical agents or air into contaminated Site groundwater while it remains in place to neutralize, precipitate, or transform the COCs/COECs initially detected in Site groundwater.

4.5.4 Potentially Applicable Groundwater Technologies

Applicable technologies and associated process options considered for remediation of the groundwater COCs/COECs (in addition to No-Action) are listed below and organized by the GRAs. These technologies/process options are described in more detail and screened in **Table 4-6**. The final column in this table identifies those technologies/process options that are retained for further screening or have been screened out (rejected).

4.5.4.1 Limited Action Response

The Limited Response Action technologies considered for Site groundwater are described in detail and screened in **Table 4-6** and include:

- Institutional Controls (ICs)
- Land-Use Controls (LUCs)
- Monitored Natural Attenuation (MNA)

4.5.4.2 Source Controls

Source controls include actions that reduce or eliminate constituent migration to groundwater from known and potential source areas. The primary source of COCs/COECs at the Site is the mine waste rock, which is found in large dumps located throughout the Site. Precipitation infiltrates the waste rock mobilizing contaminants in leachate. The contaminated leachate then percolates into the underlying groundwater system or is discharged in seeps/springs at the edges of the mine dumps. This has resulted in contaminated shallow alluvial system groundwater on both the east and west sides of the Site. Therefore, the primary source controls would be reducing or limiting water percolation through the waste rock primarily through grading and capping activities. These and other source controls are discussed as part of the evaluation of remedial technologies for upland soil and waste rock in Section 4.1 and therefore are not repeated in this section.

Preventing contaminated surface water from infiltrating to groundwater is another source control considered for the Site. This is particularly relevant for West Ballard Mine Pit (MMP035) where contaminated springs (e.g., MDS032) discharge to the mine pit where these contaminated surface waters eventually infiltrate to the regional Wells Formation hydrogeologic unit. Specific remedial technologies for remediation of discharging surface water/springs are presented in the surface water section (Section 4.3) and are not discussed further herein.

The implementation of source controls is often coupled with MNA to address the progressive cleanup of a residual groundwater plume following source control. The rationale is that once the source has been diminished or cutoff from groundwater, the existing plume will diminish in size and concentration over time by natural processes, such as biological transformation and absorption to aquifer solids.

4.5.4.3 Containment

Vertical Barriers. Vertical hydraulic barriers can consist of extraction wells, injection wells, slurry or grout walls, or a combination of these. The vertical barrier technologies considered include:

- Extraction Wells
- Extraction Trenches
- Injection Wells
- Cut-Off (Slurry or Grout) Walls

4.5.4.4 Removal and Disposal

Removal. Removal of groundwater by extraction for hydraulic control or treatment requires pumping from extraction wells or possibly cutoff/recovery trenches. The equipment required depends on the location and depth of the wells, the required flow rate, and the treatment or disposal method. Extraction and disposal of Site groundwater could reduce the volume and horizontal migration of contaminated groundwater. The removal technologies and process options potentially applicable to the COCs/COECs in the Site groundwater are described and the results of the initial screening are presented in **Table 4-6**. The removal technologies considered for Site groundwater is limited to pumping.

Disposal. Options available for the disposal of treated or untreated groundwater include recycling for beneficial reuse, land application, surface water discharge, evaporation/infiltration, discharge to a POTW, and reinjection. The disposal technologies considered include:

- Recycle/Reuse
- Land Application
- Discharge to Surface Water
- Evaporation/Infiltration Trench/Basin
- POTW
- Reinjection

4.5.4.5 Ex-Situ Treatment

Ex-situ treatment technologies would be performed in conjunction with groundwater removal to treat the extracted groundwater to acceptable levels to allow for discharge, disposal or recycling. The treatment technologies need to be considered for their ability to reduce the concentrations of primarily selenium but also arsenic and cadmium. If discharge is to surface water or the extracted water has another beneficial use, then additional contaminants and potential limits will have to be considered.

The in-situ treatment technologies considered include:

- **Physical Treatment** – primarily separates or replaces the element or compound in the water being treated. The physical treatment process options evaluated include:
  - ✓ Solid/Water Separation
  - ✓ Filtration
  - ✓ Adsorption
  - ✓ Ion Exchange
  - ✓ Membrane Technologies
- **Chemical Treatment** – involves processes where the COCs are altered into a less toxic form or precipitated from solution. Chemical treatment process options evaluated include:
  - ✓ Solvent Extraction

- ✓ Chemical Precipitation
- ✓ Oxidation/Reduction

- **Thermal Treatment** – involves the application of energy in the form of heat to catalyze and immobilize or detoxify the COCs/COECs, or to destroy them through generation of non-toxic constituents (e.g., water and carbon dioxide). Thermal treatment process options evaluated include:
  - ✓ Evaporation/Distillation
  - ✓ Wet Air Oxidation
- **Biological Treatment** – consists of enhancing the biological transformation of constituents by microorganisms to less mobile species.

4.5.4.6 In-Situ Treatment

In-situ treatment technologies are designed to treat contaminated groundwater without extracting the water. The treatment technologies need to be considered for their ability to reduce the concentrations of primarily selenium but also arsenic and cadmium. The in-situ treatment technologies considered for Site groundwater include:

- **Physical Treatment** – primarily separates or replaces the element or compound in the water being treated. The physical treatment process option evaluated includes:
  - ✓ Mechanical Aeration
- **Chemical Treatment** – involves processes where the COCs are altered into a less toxic form or precipitated from solution. Chemical treatment process options evaluated include:
  - ✓ Chemical Injection (Oxidation/Reduction/Hydrolysis)
  - ✓ Permeable Reactive Barrier (PRB)/Chemical Injected Reductive Reaction Zone
- **Thermal Treatment** – involves the application of heat to immobilize, detoxify, or destroy inorganic compounds. The thermal treatment process option evaluated includes:
  - ✓ In-Situ Thermal Desorption
- **Biological Treatment** – consists of enhancing the biological transformation of constituents by microorganisms to less mobile species. In-situ biological treatment may be facilitated by introducing a carbon source and nutrients to the treatment zone.

Table 4-1
Ballard Mine Waste Rock Dump and Mine Pit Areas and Volumes
Ballard Site

Waste Rock Dump/Mine Pit[(1)]	Net Fill Volume (cu. yd.)	Net Excavated Volume (cu. yd.)	Map Area[(2)] (sq. ft.)	Surface Area[(3)] (sq. ft.)
MWD080	4,990,000	---	3,520,000	3,670,000
MWD081	3,920,000	---	2,060,000	2,180,000
MWD082	3,040,000	---	3,170,000	3,330,000
MWD083	608,000	---	727,000	760,000
MWD084	1,140,000	---	1,270,000	1,320,000
MWD093	5,060,000	---	2,860,000	3,030,000
MMP035	---	13,200,000	4,030,000	4,730,000
MMP036	---	5,850,000	2,680,000	2,970,000
MMP037	---	2,660,000	1,020,000	1,150,000
MMP038	---	21,800	56,200	60,200
MMP039	---	844,000	1,030,000	1,100,000
MMP040	---	1,230,000	905,000	982,000
MMP035 In-Pit	NA	---	*1,129,363*	*1,162,395*
MMP036 In-Pit	NA	---	*891,515*	*917,238*
TOTAL[(4)]	**18,800,000**	**23,800,000**	**23,300,000**	**25,300,000**
Acres:			**534**	**581**

Notes:

Calculated areas and volumes have been rounded to three significant figures.

(1) Mine features are shown on Drawing 4-1.

(2) Map area is the area in a horizontal (flat) map view.

(3) Surface area is the 3D area that accounts for topographic variations (slopes).

(4) Areas of in-pit waste rock fills are not included in the total areas as this area is already captured in the excavated pit area.

In-Pit In pit waste rock dumps.

--- not applicable

NA not available; the pit topography prior to waste rock deposition is not available, so a volume cannot be calculated.

Table 4-2
Summary of Initial Upland Soil/Waste Rock Technology Screening
FEASIBILITY STUDY TECHNICAL MEMORANDUM #1
P4 Production LLC, Ballard Mine, Idaho

<table>
<tr><th colspan="5">BALLARD MINE UPLAND SOIL/WASTE ROCK</th></tr>
<tr><th>General Response Action</th><th>Treatment Technologies</th><th>Process Options Considered</th><th>Site Specific Considerations - Selection Rationale</th><th>Initial Screening Results</th></tr>
<tr><td>No Action</td><td>No Action</td><td>NA</td><td>The No-Action alternative is required for consideration under the NCP as part of the FS Process. The No-Action alternative would be considered if remediation efforts cause substantial risk to human health or the environment during implementation or when the cost of remediation is excessive compared to the benefits of the risk reduction achieved.</td><td>Retain</td></tr>
<tr><td rowspan="2">Limited Action Response</td><td>Institutional Controls (ICs)</td><td>Government controls, proprietary controls, enforcement tools, and informational tools</td><td>Typical examples of governmental controls include zoning; state, or local land use restrictions; and sports/recreational limits posed by federal, state and/or local resources and/or public health agencies. Proprietary controls include easements that restrict use (also known as negative easements) and restrictive covenants. These types of controls can prohibit activities that may compromise the effectiveness of the response action or restrict activities or future resource use that may result in unacceptable risk to human health or the environment. State and tribal law typically authorize proprietary controls. ICs are a viable option for the Ballard Site as they help to limit human and ecological exposures.</td><td>Retain</td></tr>
<tr><td>Land Use Controls (LUCs)</td><td>Fencing and other LUCs</td><td>LUCs include engineering and physical barriers, such as fences and security guards, as well as institutional controls (ICs). Neither ICs nor LUCs reduce the mobility, toxicity, or volume of COCs/COECs. However, ICs/LUCs may prevent human exposure to the COCs/COECs and preserve the integrity of the overall remedy. LUCs are a viable option for the Ballard Site as they would limit human and ecological exposures. It is likely that LUCs would be incorporated into the overall Site remedy during remedial construction and until long-term monitoring show that RAOs are achieved.</td><td>Retain</td></tr>
<tr><td rowspan="5">Containment</td><td rowspan="4">Cover System</td><td>Multi-Layered Cap</td><td>This process option involves construction of a multiple-layered cap with at least one hydraulic barrier layer consisting of earthen materials of various gradations, a compacted clay layer, a geosynthetic clay layer, or a geomembrane layer. In addition to the hydraulic barrier layer, the cap would incorporate a drainage layer and vegetation layer. Due to the semi-arid location of the Site, compacted clay layers may be subjected to desiccation and cracking due to shrinkage of the clay. Multi-layer caps are a viable cover system option for the Ballard Site as they limit direct human and ecological exposures as well as limit or mitigate impacts to surface water and groundwater at the Site.</td><td>Retain</td></tr>
<tr><td>Asphalt/Concrete Cap</td><td>Asphalt and concrete caps area are constructed of a gravel sub-base layer overlain by asphalt or concrete. Asphalt and concrete caps are able to withstand traffic and are thus particularly suited for areas that will potentially receive future traffic. These caps are effective at both reducing infiltration of precipitation and eliminating direct contact with COCs/COECs. However, due to the high unit weight of these materials and cost, they would only be considered for small areas with material of sufficient bearing strength. Due to the large areas that would be covered during Site remediation, cost of construction and maintenance as well as the aesthetic concerns associated with this type of cover in a natural environment, asphalt and concrete caps have been <u>eliminated</u> from further consideration.</td><td>Reject</td></tr>
<tr><td>ET Cap</td><td>RCRA Subtitle D provides that a regulatory agency may approve an ET soil cover, commonly referred to as an alternative final cover (AFC), if the alternative design includes an infiltration layer that will result in the net reduction in infiltration equivalent to that provided by conventional covers. The thickness of the soil layer is chosen to allow for sufficient storage of all infiltration water during periods of low ET. The movement of water from the soil to the atmosphere is controlled by the amount of evaporation and transpiration by vegetation, which are greatest during the warm and dry growing seasons.
ET covers consist of single or multiple soil layers to store precipitation that is then removed by vegetation through evaporation and transpiration. ET soil covers are readily implementable due to the fact that they are constructed of readily available native soil and vegetation. The majority of caps constructed at mining sites in the western United States and in the phosphate mine area of southeastern Idaho, are ET soil covers of varying designs. ET caps are a viable option for the Ballard Site as they limit direct human and ecological exposures as well as limit or mitigate impacts to surface water and groundwater at the Site.</td><td>Retain</td></tr>
<tr><td>Soil Cover Cap</td><td>A soil cover cap involves placement of one foot or more of native soil over fill over waste rock. The main objective of this cap is to prevent direct exposure to the waste rock and provide media for revegetation. Although it is not designed as an ET cover, it may function in a similar manner. Soil covers limit direct exposure to COCs/COECs contained in waste rock. The thickness of a soil cover must be sufficient to prevent uptake of COCs/COECs by vegetation that grows on the cover. Soil cover caps are a possible option for the Ballard Site as they limit direct human and ecological exposures and depending on their thickness, limit or mitigate impacts to surface water and groundwater at the Site.</td><td>Retain</td></tr>
<tr><td>Vertical Barrier</td><td>Sheet Piling/Grout Wall</td><td>Vertical barriers are used in soil to restrict the lateral migration of COCs/COECs in Site soils and include the construction of sheet pile or grout walls to prevent lateral migration of COCs/COECs through soils away from areas of concern (i.e., a source area). The Ballard RI Report data indicate that in their current state, COCs/COECs such as metals have not significantly migrated away from areas of release (e.g., mass wasting off the dumps) and limited dispersion of soil COC/COECs occur in downstream drainages (e.g., sediment and riparian soils). Based on the RI findings indicating that there is insignificant off-dump (lateral) migration of metal COCs/COECs in Site upland soils/waste rock, vertical barriers are not necessary to contain Site contaminants lateral migration. As a result, vertical barriers have been <u>eliminated</u> from further consideration..</td><td>Reject</td></tr>
</table>

The treatment technologies and/or process options in the shaded cells have been eliminated from further evaluation in Section 5.

Table 4-2
Summary of Initial Upland Soil/Waste Rock Technology Screening
FEASIBILITY STUDY TECHNICAL MEMORANDUM #1
P4 Production LLC, Ballard Mine, Idaho

BALLARD MINE UPLAND SOIL/WASTE ROCK				
General Response Action	**Treatment Technologies**	**Process Options Considered**	**Site Specific Considerations - Selection Rationale**	**Initial Screening Results**
Containment (cont.)	Surface Controls	Soil Grading	Soil grading involves altering the topography of the Site to control and direct surface water away from impacted areas and to prevent ponding of surface water. Grading is a viable process option for the Ballard Site to reduce infiltration of precipitation into waste rock and could be incorporated as a component of the overall Site remedy.	Retain
		Revegetation	Revegetation involves applying a soil layer followed by seeding with an appropriate seed mix to revegetate an area. Vegetation promotes the reduction of runoff, erosion and infiltration of precipitation. Revegetation is a viable process option for the Ballard Site and could be incorporated into the overall Site remedy.	Retain
Removal and Disposal	Removal	Conventional Excavation	Conventional excavation involves the use of excavation equipment such as backhoes, trackhoes, scrapers, front-end loaders, and/or bulldozers to dig, scrape or push materials which require treatment, relocation, or contouring. Conventional excavation could be used to remove materials within the area for one or more of the following: 1) removal of overlying soil/waste rock materials to un-impacted native soil, or 2) for contouring an area prior to application of a cap. The removed materials then would be further treated, consolidated, placed under a cap or used in the construction of a cover system. Excavation is a viable process option and could be easily implemented in various areas of the Ballard Site where these materials might be excavated for consolidation or reuse during remediation.	Retain
	Disposal	Consolidation and On-Site Disposal/Backfilling	Consolidation and on-site disposal at the Ballard Site would likely include backfill of the open pits with on-Site waste rock. Consolidation and on-site disposal or backfilling is a viable process option and would be beneficial to reduce the overall footprint of impacted waste rock.	Retain
		Off-Site Disposal	Off-site disposal is less desirable than on-site consolidation/disposal due to the increased risk to public safety and health as a result of the increased possibility of transportation accidents and public exposure to possible spills. Given that there are in excess of 18 million cubic yards of contaminated upland soils/waste rock at the Site, offsite disposal is not a viable option and is <u>eliminated</u> from further consideration.	Reject
Ex-Situ Treatment	Physical	Stabilization/Solidification	Ex-situ stabilization generally involves excavation of the solids, mechanical mixing of the solids with stabilization agents, curing of the mass for optimal reduction in leachability, and then on-site or off-site disposal. Various types of stabilization agents are available, including cement, fly ash, silica, bentonite, and various polymers. The types of stabilization agents used depend on the chemical composition of the material being stabilized. Stabilization and solidification has been shown to be effective for reducing the leachability of heavy metals. Due to the large volumes of upland soils/waste rock and relatively low concentrations of COCs/COECs, stabilization/solidification is not a viable option and is <u>eliminated</u> from further consideration.	Reject
		Dewatering	Dewatering is not an appropriate technology for soils and waste rock being considered for the Ballard Site because the material is unsaturated (i.e., does not contain free liquid). As a result, dewatering is not an effective process option and is <u>eliminated</u> from further consideration.	Reject
		Separation	Separation is a process whereby soils are slurried, and then passed through a gravity separation process to remove or extract organics. Physical separation also can be implemented through the use of screens and grizzlies to break soils down into discrete sizes. Separation is most effective where there is a significant difference in particle size and the constituents of concern are concentrated in a narrow range of sizes. It is also effective where free metals are present and can be selectively removed. These conditions are not present in the impacted soils at the Ballard Site; therefore physical separation is not a viable option and is <u>eliminated</u> from further consideration.	Reject
	Chemical	Soil Washing	Soil washing is an aqueous-based technology that generally uses a mechanical process to separate particles that contain contaminants. In addition, aqueous chemicals (e.g., acids) can be used to extract COCs/COECs from the soil matrix. The COCs/COECs are captured in the chemical solution and subsequently disposed at a permitted facility. Due to the large volumes of upland soils/waste rock and relatively low concentrations of COCs/COECs, soil washing is not a viable option and is <u>eliminated</u> from further consideration.	Reject
		Chemical Oxidation	Chemical oxidation involves the addition of chemical agents to react with COCs/COECs in the soil to form oxidized by-products. Chemical oxidation is effective for slurries and sludges containing organics and inorganics. It may be effective for fixation of some metals into insoluble form that will not fail toxicity characteristic leaching procedure (TCLP) criteria. However, chemical oxidation has not been demonstrated to be effective for all inorganics and treatment of the large volume of waste rock present at the Site would not be practical. As a result, chemical oxidation is <u>eliminated</u> from further consideration.	Reject
		Chemical Extraction	Chemical extraction is a technology that utilizes a multiple stage process in which soils are excavated, screened, washed with a surfactant or other chemical extractant then separated. This technology has been used primarily for soils contaminated with a variety of organic constituents. However, COCs/COECs at the Ballard Site are primarily inorganic and chemical extraction has not been demonstrated effective for removal of these constituents. As a result, chemical extraction is not a viable option and is <u>eliminated</u> from further consideration.	Reject
	Thermal	Incineration	Incineration is a thermal process where soil and other wastes are treated at elevated temperatures (1,400 to 2,200 °F) to volatilize and combust contaminants. Heavy metals and radionuclides in the upland soil and waste rock would not be oxidized to a significant extent and would remain	Reject

The treatment technologies and/or process options in the shaded cells have been eliminated from further evaluation in Section 5.

BALLARD MINE UPLAND SOIL/WASTE ROCK				
General Response Action	**Treatment Technologies**	**Process Options Considered**	**Site Specific Considerations - Selection Rationale**	**Initial Screening Results**
			in the residual ash from the incinerator and likely would require proper off-site disposal in a commercial hazardous waste landfill. Additionally, the volume of Site material makes thermal treatment impractical. Incineration is eliminated from further consideration.	
Ex-Situ Treatment (cont.)	Thermal (cont.)	Thermal Desorption	Thermal desorption is used to treat soil and sludge by heating the material (200 to 600 °F) to volatilize organic contaminants and separate them from the solid matrix without combustion. The volatilized contaminants (vapors) are collected and treated by one or more off-gas treatment technologies. However, COCs/COECs at the Ballard Site are inorganic and thermal desorption would not reduce concentrations of these constituents. As a result, thermal desorption is not a viable option and is eliminated from further consideration.	Reject
	Biological	Various ex-situ processes	Ex-situ biological treatment of soils and solids consists of enhancing the biological degradation of organic constituents by microorganisms. Biological treatment typically is implemented by creating favorable conditions for microbial activity to degrade organic constituents and is generally effective for organics, but is not suitable for the Site COCs/COECs. As a result, biological treatment is not a viable option and is eliminated from further consideration.	Reject
In-Situ Treatment	Physical	Stabilization/Solidification	In-situ stabilization (i.e. fixation) involves mechanical mixing of the solids in-place with stabilization agents to reduce the solubility or mobility of the COCs/COECs. Various types of stabilization agents are available, including cement, fly ash, silica, bentonite, and various polymers. The types of stabilization agents that are used depend on the chemical composition of the material being stabilized. Stabilization and fixation has been shown to be effective for reducing the leachability of heavy metals. However, in-situ stabilization/solidification is not a viable treatment processes because the volume of materials that would require stabilization/solidification is very large. Therefore stabilization/solidification is eliminated from further consideration.	Reject
		Soil Vapor Extraction	Soil vapor extraction is a common technology used for the remediation of soils containing volatile organic contaminants. The primary constituents associated the Ballard Site are not volatile organic contaminants. As a result, soil vapor extraction is not a viable option and is eliminated from further consideration.	Reject
	Chemical	Various in-situ processes	In-situ application of chemical treatment processes has occurred at bench-scale levels in association with the remediation other CERCLA sites; however, it would be difficult to assess overall performance (i.e., if complete treatment has been achieved) of in-situ chemical treatment processes under full scale implementation. As a result, large scale in-situ chemical treatment processes is not a viable option for the Ballard Site and is eliminated from further consideration.	Reject
	Thermal	Vitrification	Vitrification is a thermal treatment process that immobilizes inorganic compounds and destroys organic compounds by electrically heating and fusing the soil into a stable, glass-like block. Vitrification usually is performed on relatively small areas of contamination due to the high energy consumption required to vitrify the matrix and is not implementable for the large quantities of impacted soil at the Ballard site. As a result, in-situ vitrification is not a viable option and is eliminated from further consideration.	Reject
		Thermal Desorption	In-situ thermal desorption (ISTD) uses thermal wells, paired with heated extraction wells to remediate COCs/COECs. Heat is applied to soil from a high-temperature surface in contact with the soil (i.e., the thermal well), so that radiation and thermal conduction heat transfer are effective near the heated extraction wells. ISTD primarily has been used to treat organic contaminants, which are not the primary constituents associated the Ballard Site. As a result, thermal desorption is not a viable option for Site COCs/COECs and is eliminated from further consideration.	Reject
	Biological	Various In-situ processes	In-situ biological treatment of soils and solids consists of enhancing the existing biological degradation of organic constituents by microorganisms. In-situ biological treatment processes would not be effective or implementable on COCs/COECs present at the Ballard Mine site (i.e., metals and radionuclides). Biological in-situ treatment of upland soils/waste rock is eliminated from further consideration.	Reject

The treatment technologies and/or process options in the shaded cells have been eliminated from further evaluation in Section 5.

Table 4-3
Recorded Stream Flows in Drainages that Originate in the Ballard Site
FEASIBILITY STUDY TECHNICAL MEMORANDUM #1
P4 Production LLC, Ballard Mine, Idaho

	Year	Ballard Creek		Wooley Valley Creek		
		MST067	MST066	MST090	MST089	MST088
Runoff Discharge (cfs)	2004	0	0	0.0098	0	Dry
	2006	0.10	0.62	--	3.4	6.2
	2007	0	0.064	0.054	0.026	Dry
	2008	0.034	0.12	0.071	0.26	2.4
	2009	0.064	0.34	1.2	6.62	--
	2010	Dry	0.18	0.28	0.46	--
	2012	0.0039	0.22	0.06	0.02	--
Baseflow Discharge (cfs)	2004	Dry	Dry	--	Dry	--
	2006	--	--	--	--	--
	2007	Dry	0	Dry	Dry	Dry
	2008	Dry	Dry	Dry	Dry	Dry
	2009	--	--	--	--	--
	2010	--	--	--	--	--
	2012	--	--	--	--	--

Notes:

cfs cubic feet per second
Dry no water present
0 water present but there was no observed flow or flow was so small as not to be measurable with standard equipment.
-- Location not included in sampling program for this year.

- Stations are arranged with upstream locations on a stream first.
- Runoff measurements typically occur in May and only are planned to coincide with the runoff period. The runoff flow measurement occurs during analytical sample collection and does not typically occur precisely at peak flow. Baseflow measurements typically occur in September.
- Monitoring locations shown on Drawing 2-5.

Table 4-4
Summary of Initial Surface Water Technology Screening
FEASIBILITY STUDY MEMORANDUM No.1
P4 Production LLC, Ballard Mine Site, Idaho

BALLARD MINE SURFACE WATER				
General Response Action	**Treatment Technologies**	**Process Options Considered**	**Site Specific Considerations - Selection Rationale**	**Initial Screening Results**
No Action	No Action	NA	The No-Action alternative is required for consideration under the NCP as part of the FS Process. The No-Action alternative would be considered if remediation efforts cause substantial risk to human health or the environment during implementation or when the cost of remediation is excessive compared to the benefits of the risk reduction achieved.	Retain
Limited Action Response	Land-Use Controls (LUCs)	Fencing[1] and other LUCs	Fencing could be erected to prevent access to the impacted surface water. Additionally, warning signs could be posted to deter surface water use. Fencing/signage does not reduce the mobility, toxicity, or volume of COCs/COECs; nor does fencing/signage prevent exposures to many ecological receptors. However, fencing/signage may prevent human exposure to the COCs/COECs and preserve the integrity of the overall remedy.	Retain
	Institutional Controls (ICs)	Government controls, proprietary controls, enforcement tools, and informational tools to limit Surface Water Use [1]	Typical examples of governmental controls include zoning; state or local surface water use regulations; and sports/recreational fishing limits posed by federal, state and/or local resources and/or public health agencies. Proprietary controls include acquisition of water rights to prevent future agriculture of domestic use, easements that restrict use (also known as negative easements), and restrictive covenants. These types of controls can prohibit activities that may compromise the effectiveness of the response action or restrict activities or future resource use that may result in unacceptable risk to human health or the environment. ICs do not reduce the mobility, toxicity, or volume of COCs/COECs; nor do ICs prevent exposures to many ecological receptors. However, ICs may prevent human exposure to the COCs/COECs and preserve the integrity of the overall remedy. ICs are a viable option for the Ballard Site as they help to limit human and ecological exposures.	Retain
Source Controls	Regrading/Capping	See Upland Soil/Waste Rock (Table 4-1)	Examples of source controls for the Site surface water include those technologies that eliminate or reduce the contact of precipitation with the mine waste rock. Regrading and/or capping an area are process options for limiting or eliminating water infiltration and percolation through the waste rock. Surface water diversions may also be effective where non-impacted surface water runs onto the waste rock dumps.	Retain
Containment	Sediment Control Basins	Retention Basins/Serpentine Channels	Retention basins capture storm water, resulting in a lower transport velocity, which allows sediment to settle before the water overtops the basin spillway and is discharged. A portion or all of the water is retained in the pond and may either evaporate or infiltrate. Retention basins are a common technology used as a Best Management Practice (BMP) for storm water management. This technology is used extensively at all of P4's more recent mines. Serpentine channels are another form of sediment control that may be used to slow surface water flow and encourage sediment settlement. Retention basins and serpentine channels are viable options for the Ballard Site as they mitigate off-site transport of contaminated sediment.	Retain
		Wetlands	Constructed wetlands function as containment and sediment control process options by retaining surface water and reducing its flow velocity. Biological processes then treat the surface water by removing some dissolved constituents. Wetlands also are discussed in biological treatment below. However, they are included here under "sediment control basin" for their sediment containment and filtration function and are a possible option for sediment containment at the Site.	Retain
Removal and Disposal	Removal	Containment or Removal Offsite	Removal of surface water is accomplished by collection and isolation in a pond or tank, typically for storage or treatment. Alternatively, a removal action could be eliminating the water discharging from the waste rock to the surface water channels. This technology could possibly be a component a larger remediation process; however, it is not a standalone option for surface water remediation, nor is there a removal action that is truly implementable for surface water (i.e., it is not possible to contain or remove all surface water from the Site). As a result, removal as a technology is <u>eliminated</u> from further consideration.	Reject
	Disposal	Recycle/Reuse	Recycling of surface water would be dependent on water quality and quantity. Surface water sources at the Site are largely storm water, snow melt runoff, and a few low-volume perennial seeps/spring. As such, the volume of water potentially to be managed fluctuates widely. Depending on the quality of the collected surface water and the water quality requirements for the receiving location, some degree of treatment may be required. Because the Ballard Mine is inactive, opportunities for recycling and reuse of the surface water are limited and would only be short-term (e.g., dust control during remedial construction). Lack of demand and the possible short-term uses of collected surface water, this possible disposal process option is <u>eliminated</u> from further consideration.	Reject
		Land Application[1]	Land application is a viable option and would consist of applying surface water by irrigation. The allowable quality and quantity applied would depend on land use, soil characteristics (e.g., attenuation potential), depth to groundwater, climatic conditions, and other factors. Some level of treatment may be likely if bioaccumulation in the cultivated crops is a concern or infiltration to groundwater is an issue. Land application would be appropriate spring through fall seasons, which coincides with the typical maximum discharge from the Site.	Retain

The treatment technologies and/or process options in the shaded cells have been eliminated from further evaluation in Section 5.

Table 4-4
Summary of Initial Surface Water Technology Screening
FEASIBILITY STUDY MEMORANDUM No.1
P4 Production LLC, Ballard Mine Site, Idaho

BALLARD MINE SURFACE WATER				
General Response Action	**Treatment Technologies**	**Process Options Considered**	**Site Specific Considerations - Selection Rationale**	**Initial Screening Results**
Removal and Disposal (cont.)	Disposal (cont.)	Treated Surface Water Discharge[1]	Surface water could be discharged back to the on-Site drainages after treatment. Continued input of water meeting standards would be a net benefit to the downstream Blackfoot River. A treated water discharge to the Blackfoot River system would require substantive compliance with the Clean Water Act.	Retain
		Evaporation/Infiltration	A specially designed infiltration trench or basin would have to be constructed at or near the Site for the infiltration process. There are three feasible infiltration areas at the Site: 1) into the Wells Formation in a mine pit, 2) into the alluvium if gravel or permeable sands can be found, or 3) into the basalt unit west of the Site. Some storage capacity, such as a small reservoir, would likely be necessary to address seasonal flow variations. Evaporation during the summer and fall could assist in reduction of water volume in that reservoir prior to treatment. Disposal solely by evaporation would not require additional treatment, but would only be seasonally feasible, it is likely that the volume of the pond required for storage of the spring runoff would be large, and would be considered a consumptive use of the resource.	Retain
		POTW	Discharge to a POTW would require a discharge permit and approval by the POTW. However, the Site is not reasonably close to any municipality or other POTW. As a result, discharge to a POTW is <u>eliminated</u> from further consideration.	Reject
		Injection Wells	Collected surface water could be injected directly into a groundwater aquifer using an injection well(s). The amount of injected water would be dependent upon hydrogeological conditions, water quality, and potentially on State of Idaho and Underground Injection Control (UIC) regulations. However, injection using wells is difficult to technically implement because of chemical and biological fouling, and would be no more effective than an infiltration trench or basin at a far greater expense to construct and maintain. In an area of excessive aquifer depletion, surface water injection could be favorable; however, this is not known to be the case in the Site vicinity. Accordingly, injection to groundwater is <u>eliminated</u> from further consideration.	Reject
Ex-Situ Treatment	Physical	Solid/Water Separation[1]	Separation consists of mechanical and gravity methods for bulk removal of suspended solids from surface water. This is a more mechanical approach compared to the sedimentation basins discussed previously. Considering that most of the surface water COCs/COECs are in the dissolved phase, separation would not be sufficient as a standalone process option, but could be incorporated into the treatment train of a larger treatment system. A simple settling pond or wetlands also could serve the same function, as discussed above in the containment section. Because this technology could be part of a larger treatment system, it is retained.	Retain
		Filtration[1]	Filtration is applicable for a wide range of solid sizes, but is not effective for removal of dissolved constituents. Filtration is primarily used for final polishing downstream of gross solid/water separation. Although filtration of some solids may be incorporated into an overall treatment design, it would not be effective as a standalone technology for dissolved constituents. However, because this technology could be part of a larger treatment system, it is retained.	Retain
		Adsorption	Adsorption uses various adsorbents such as ferrihydrite, activated alumina, activated carbon, etc. to remove dissolved phase constituents from surface water. Adsorption is a viable option as it could be capable of removing constituents such as selenium to levels below clean up criteria. However, overall performance typically is related to site specific water chemistry and selenium speciation with certain forms of selenium being more amenable to adsorption than others. This technology is retained for further screening.	Retain
		Ion Exchange (IX)	IX is a treatment technology in which cation and anion exchange resins are used to remove ions from water/wastewater. IX resins are selected to preferentially remove specific ions from the feed water and replace them with highly soluble, non-toxic forms. Due to generation and rinsing requirements, the IX process would result in waste materials, which would require further handling and treatment. Fouling of the resin is also a concern. However, IX may be an appropriate option for arsenic and selenium in combination with other technologies and is retained for further consideration.	Retain

The treatment technologies and/or process options in the shaded cells have been eliminated from further evaluation in Section 5.

Table 4-4
Summary of Initial Surface Water Technology Screening
FEASIBILITY STUDY MEMORANDUM No.1
P4 Production LLC, Ballard Mine Site, Idaho

BALLARD MINE SURFACE WATER				
General Response Action	**Treatment Technologies**	**Process Options Considered**	**Site Specific Considerations - Selection Rationale**	**Initial Screening Results**
Ex-Situ Treatment (cont.)	Physical (cont.)	Membrane Technologies	Membrane technologies include reverse osmosis (RO), nanofiltration (NF) and electrodialysis/electrodialysis reversal (ED/EDR). RO and NF are physical treatment processes in which pressurized water is passed through a semi-permeable membrane. ED is a very effective membrane process that employs an electronic field as the driving force for separating a liquid influent into a concentrated waste stream and clean effluent. EDR periodically alternates the current for cleaning of the membranes, which requires addition piping and controls. The membrane technologies remove most dissolved particulate and ions from the water and can be the most effective method for reducing sulfate and TDS concentrations. Depending upon the feedwater concentrations, the waste brine may be as much as 15-percent to 25-percent of the total feedwater flow. The brine would require further handling and/or treatment prior to disposal. Membrane technology is a viable option and may offer advantages as an initial treatment step to reduce the total amount of water treated by another primary method or it may also be effective as a final polishing step.	Retain
	Chemical	Solvent Extraction	Solvent extraction is the separation of constituents from a liquid by contact with another immiscible liquid. Solvent extraction is effective on organic constituents, but is not an effective treatment method for metals removal. Therefore, solvent extraction is not an appropriate technology for COCs/COECs in Site surface water and is eliminated from further consideration.	Reject
		Chemical Precipitation	Chemical precipitation is a treatment method in which dissolved metal ions and/or dissolved salts are precipitated in the form of insoluble salts. Precipitation is the result of the addition of chemicals to reach chemical saturation and/or is achieved by varying the pH. The insoluble salts (the precipitate) may be removed from the water using a combination of sedimentation, coagulation, flocculation, and/or filtration. Chemical precipitation is a viable option as it is a commonly used technology for removal of metals.	Retain
		Oxidation/Reduction	Chemical oxidation and reduction, such as ozonation, chlorination, hydrogen peroxide, and ultraviolet light, employs agents that raise or lower the oxidation states of COCs/COECs. Oxidation/reduction reactions may improve the separation characteristics of inorganics and could be used with other technologies for treatment of Site COCs. Biological reduction also is an effective method of treatment for selenium and the other Site COCs, as such this process option is retained.	Retain
	Thermal	Evaporation/Distillation	Evaporation is a process in which water is heated to the boiling point. The water vapor is condensed to form condensate (distilled water), which is a clean product. The COCs/COECs are concentrated in the brine that remains following the heating process. Mechanical evaporation may be an applicable process option for COCs/COECs in conjunction with other technologies.	Retain
		Wet Air Oxidation	Wet air oxidation is a combustion process that occurs in the liquid phase by adding air at high temperatures and pressure. While the process is effective at destroying organic compounds, it is not considered effective for inorganics. Therefore, wet air oxidation is not an appropriate technology for COCs/COECs in Site surface water and is eliminated from further consideration.	Reject
	Biological	Biological	Biological treatment involves the transformation, degradation, or fixation of contaminants by microorganisms. Bioreactor treatment can range from simple field systems to more complex treatment plants. For example, microbial activities can transform organic components to intermediate by-products and basic constituents (e.g., carbon and water), thus reducing concentrations of biodegradable organic compounds. The most common form of biological treatment for metals and some non-metals, like selenium, is biological reduction using anaerobic bacteria followed by precipitation or absorption of the COC/COEC. This reduction can also generate sulfide, which will result in the formation metal sulfides and thus removing many cationic metals from solution. This process option may be conducted in an anaerobic wetlands or a bioreactor. Biological treatment is becoming one of the most common and effective selenium treatment methods. Simple systems may be characterized as in situ. P4 tested a bioreactor system for the treatment of dump seep water at the Site with favorable results for selenium, arsenic, cadmium and several other metals (P4, 2011). The test system consistently produced treated water that had selenium concentrations below the groundwater MCL (0.05 mg/L), but would need modifications to consistently meet the surface water standard of 0.005 mg/L, especially when the temperatures drop in the fall and the biological activity is reduced.	Retain
In-Situ Treatment	Physical	Mechanical Aeration	Involves injecting air into a surface impoundment or channel containing the surface water to aerate the water and result in metal precipitation. While this could be beneficial at some seeps and springs, the additional mechanical aeration is not like to aerate the water much beyond that what naturally occurs currently at or near the seep/spring discharge locations. Mechanical aeration would not be effective for treatment of selenium or many of the other Site COCs/COECs and is therefore eliminated from further consideration.	Reject

The treatment technologies and/or process options in the shaded cells have been eliminated from further evaluation in Section 5.

Table 4-4
Summary of Initial Surface Water Technology Screening
FEASIBILITY STUDY MEMORANDUM No.1
P4 Production LLC, Ballard Mine Site, Idaho

BALLARD MINE SURFACE WATER				
General Response Action	**Treatment Technologies**	**Process Options Considered**	**Site Specific Considerations - Selection Rationale**	**Initial Screening Results**
In-Situ Treatment (cont.)	Chemical	Chemical Injection (Oxidation /Hydrolysis)	Chemical agents are directly injected into the impacted water. For the reduction of the broad list of COCs/COECs at the Site, this technology is not appropriate and is therefore eliminated from further consideration.	Reject
		Permeable Reactive Barrier (PRB)	Permeable reactive barriers (PRB) consist of reactive materials placed in berm or cell in which the surface water must pass through. Typically, the surface water is flowing under its natural gradient thereby creating a passive surface water treatment system. PRBs are commonly used for shallow groundwater, but would be difficult to implement in a surface water configuration.	Reject
	Thermal	Thermal Desorption	In-Situ Thermal Desorption (ISTD) is not an appropriate technology for the treatment of surface water and is eliminated from further consideration.	Reject
	Biological	Biological	In-situ and ex-situ biologic treatment are only significantly different in location of the system (i.e., above the ground or within treatment cells or wetlands). As such, the above discussion of ex-situ biologic treatment is relevant here. A wetlands or bioreactor type system is a viable technology for the treatment of the Site surface water COCs/COECs. Such a system if constructed directly in the seep location or in the stream channel could be considered in situ if flow was passive. Such systems have proven less expensive and effective for treatment selenium (CH2M Hill, 2013).	Retain

Notes:
(1) – These technologies and process options would only be used as part of another technology, for example as a way to discharge treated water, or as part of a larger treatment system, e.g., filtration after chemical precipitation.

The treatment technologies and/or process options in the shaded cells have been eliminated from further evaluation in Section 5.

Table 4-5
Summary of Initial Sediment/Riparian Soil Technology Screening
FEASIBILITY STUDY TECHNICAL MEMORANDUM #1
P4 Production LLC, Ballard Mine, Idaho

BALLARD MINE SEDIMENT/RIPARIAN SOIL				
General Response Action	**Treatment Technology**	**Process Option Considered**	**Site Specific Considerations - Selection Rationale**	**Initial Screening Results**
No Action	No Action	NA	The No-Action alternative is required for consideration under the NCP as part of the FS Process. The No-Action alternative would be considered if remediation efforts cause substantial risk to human health or the environment during implementation or when the cost of remediation is excessive compared to the benefits of the risk reduction achieved.	Retain
Limited Action Response	Institutional Controls (ICs)	Government controls, proprietary controls, enforcement tools, and informational tools to limit site access and activities	Typical examples of governmental controls include zoning; state or local groundwater and surface water use regulations; and sports/recreational fishing limits posed by federal, state and/or local resources and/or public health agencies. Proprietary controls include easements that restrict use (also known as negative easements) and restrictive covenants. These types of controls can prohibit activities that may compromise the effectiveness of the response action or restrict activities or future resource use that may result in unacceptable risk to human health or the environment. State and tribal law typically authorize proprietary controls. ICs do not reduce the mobility, toxicity, or volume of COCs/COECs; nor do ICs prevent exposures to many ecological receptors. However, ICs may prevent human exposure to the COCs/COECs and preserve the integrity of the overall remedy. ICs are a viable option for the Ballard Site as they help to limit human and ecological exposures and have been retained for further consideration.	Retain
	Land Use Controls (LUCs)	Fencing to limit site access and activities and or signage to deter activities.	Fencing could be erected to prevent access to all or portions of the impacted sediment/riparian soil. Warning signs could be posted to deter activities such as harvesting culturally significant plants. Fencing/signage does not reduce the mobility, toxicity, or volume of COCs/COECs; nor does fencing/signage prevent exposures to many ecological receptors. However, fencing/signage may prevent human exposure to the COCs/COECs and preserve the integrity of the overall remedy. LUCs are a viable option for the Ballard Site as they help to limit human and ecological exposures and are retained for further consideration.	Retain
	Monitored Natural Recovery (MNR)	Source Control (see Upland Soil/ Waste Rock table); Long-term Monitoring of Sediment/Riparian Soil and Culturally Significant Vegetation	Monitored Natural Recovery (MNR) is a limited action response where ongoing, naturally occurring processes contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediment (USEPA, 2005). These natural processes are combined with long-term monitoring (LTM) to evaluate the reduction in risks to human health and the environment over time. In order to be successful, MNR relies on control of up gradient sources of contamination. Key advantages of MNR include its non-invasive nature and its relatively low implementation cost. Disadvantages of MNR include generally longer remediation timeframes when compared with active remedies and uncertainties related to erosion/sedimentations rates and the resulting impacts to the secondary media (i.e., culturally significant plants). Considering the potential impact of sediment removal activities, MNR is a viable process option for the Ballard Site as it reduces exposure to Site COCs/COECs to human and ecological receptors over time without disturbance to stream channels and is retained for further consideration.	Retain
Containment	Cover Systems	In-situ capping - clean soil placed over the contaminated media; or rock armoring/ biostabilization - inert natural rock materials, riprap, vegetation, and/or wood debris placed over the contaminated media.	Consists of placement of a clean material over the existing contaminated material that is intended to remain in place indefinitely. Existing vegetation would be removed prior to construction of any cover system, and typically the cover system or portions of the cap would be revegetated with the appropriate seed mixture. Simple cover systems are constructed of granular materials, such as clean sediment, sand, or gravel. More complex cover designs can include geotextiles, liners, and other permeable or impermeable elements in multiple layers that may include additions of material to attenuate the flux of contaminants (e.g., organic carbon). This process option <u>is not retained</u> because the dynamic nature of the intermittent streams (ongoing erosional and depositional forces) would make it difficult to maintain a permanent cover system.	Reject
	Channelization	Straighten and line sections of the natural drainages	Existing drainages would be straightened and lined to isolate contaminated sediment/riparian soil. Although the remedial design may include areas of channelized drainages to divert surface water away from sources of contamination or covers/caps on Site, channelization <u>is not retained</u> as a remedial technology for sediment/riparian areas and their soil. Channelization is not a viable process option because the resulting loss of ecological habitat likely would outweigh the risk reduction that would result from channelizing the intermittent drainages.	Reject
Removal and Disposal	Removal	Sediment traps/basins in specific locations	Sediment traps or basins would be constructed in the drainages to capture contaminated sediment before they are transported further downstream. The sediment traps/basins would require periodic maintenance to clear and dispose of the accumulated sediment. These likely would be most useful where there are clearly defined swales or channels in the intermittent streams. Sediment traps are a viable process option for the Ballard Site as they would help to reduce migration of Site contaminants and would be incorporated into the overall Site remedy.	Retain

The treatment technologies and/or process options in the shaded cells have been eliminated from further evaluation in Section 5.

Table 4-5
Summary of Initial Sediment/Riparian Soil Technology Screening
FEASIBILITY STUDY TECHNICAL MEMORANDUM #1
P4 Production LLC, Ballard Mine, Idaho

BALLARD MINE SEDIMENT/RIPARIAN SOIL				
General Response Action	**Treatment Technology**	**Process Option Considered**	**Site Specific Considerations - Selection Rationale**	**Initial Screening Results**
		Conventional excavation	Conventional excavation involves the use of excavation equipment such as hydraulic excavators, backhoes, trackhoes, scrapers, front end loaders, and/or bulldozers. Excavation is a viable process option and could be implemented at various locations where the more highly contaminated materials might be excavated for consolidation with upland soils and waste rock during the remedial action. Excavation work would result in disturbance to existing stream channels, which may outweigh risk reductions from removal of the material.	
		Suction Dredging/Hydraulic Pumping	This process uses high-capacity pumps to remove water-slurried sediment. This process option is not viable and <u>is not retained</u> because it is assumed that the sediment/riparian soil can be more easily removed using the conventional excavation techniques described above.	Reject
	Disposal	On-Site consolidation and disposal of excavated materials	The excavated sediment/riparian soil would be consolidated in the upland areas and covered and/or treated along with the upland soil/waste rock. The COCs/COECs in the sediment/riparian soil are sourced from the upland soil; therefore, the selected remedy for the upland soil also would be effective for the sediment/riparian soil. On-site consolidation is a viable process option and would be beneficial in reducing the overall footprint of impacted sediment and riparian soil and is retained for further consideration.	Retain
		Off-Site transport and disposal of excavated materials	The excavated sediment/riparian soil would be transported off-Site and disposed of at a permitted treatment and disposal facility. Although technically implementable, offsite disposal <u>is not retained</u> because any sediment/riparian soil that are excavated likely would be consolidated and remediated along with the contaminated soil/waste rock in the mined area (see Section 4.1).	Reject
In-Situ/Ex-Situ Treatment	Solidification/Stabilization	Various amendments	In-situ S/S typically involves the addition of binding agents to an area of sediment/soil, followed by in-place mixing with the bucket of a backhoe to stabilize the sediment/riparian soil in place. Ex-situ S/S field processes involve excavation and staging of the solids, screening to remove large diameter materials, blending the binding agents, and stockpiling treated solids for testing prior to shipment off site or placement back in the excavation. S/S is a viable process option for the Ballard Site as it could be used to reduce the mobility of contaminants thereby reducing exposure to COCs/COECs to human and ecological receptors.	Retain
	Vitrification	High-temperature solidification	Vitrification is an in-situ or ex-situ thermal-treatment process that immobilizes inorganic compounds and destroys organic compounds by electrically heating and fusing the soil into a stable, glass-like block. The vitrification process is highly energy consumptive and is typically suitable for highly contaminated media and relatively small areas of contamination. Although technically implementable, vitrification <u>is not retained</u> from further consideration because of the distribution and relatively low concentrations of COCs/COECs in the sediments/riparian soils, high energy costs associated with the process, and other technologies that are more suitable for the Site COCs/COECs.	Reject
	Soil Washing	Chemical extraction	Soil washing (chemical extraction) is a process where aqueous chemicals (e.g., acids) are used to extract COCs/COECs from the sediment/riparian soil matrix. The COCs/COECs are captured in the chemical solution and subsequently disposed at a permitted facility. Soil washing typically is performed on excavated soil, but also can be performed in situ if site conditions allow the chemicals to be injected into and extracted from the undisturbed substrate. Although this technology might be technically implementable, this process option <u>is not retained</u> for further evaluation given the low concentrations of COCs/COECs, and the volume and distribution of sediment/riparian soil at the Site.	Reject
	Phytoremediation	Phytoextraction	Phytoremediation is an in-situ strategy that uses vegetation to remove COCs/COECs from the sediment/riparian soil. Specifically, phytoextraction is the process where plant roots uptake metal contaminants from the soil and translocate them to the above-ground plant tissues. Phytoextraction would involve controlled planting, harvesting, and off-Site disposal of plants with suitable characteristics (e.g., heavy-metal tolerant, fast growing, profuse root systems, high bioaccumulation factor). Although technically implementable, the process of planting and harvesting plants containing the Site contaminants only transfers the COCs/COECs to a secondary medium that then has to be harvested, handled and properly disposed. As a result, phytoremediation is not a viable treatment technology and <u>is not retained</u> for further analyses.	Reject

The treatment technologies and/or process options in the shaded cells have been eliminated from further evaluation in Section 5.

Table 4-6
Summary of Initial Groundwater Technology Screening
FEASIBILITY STUDY MEMORANDUM No.1
P4 Production LLC, Ballard Mine Site, Idaho

BALLARD MINE GROUNDWATER				
General Response Actions	**Treatment Technologies**	**Process Options Considered**	**Site Specific Considerations - Selection Rationale**	**Initial Screening Results**
No Action	No Action	NA	The No-Action alternative is required for consideration under the NCP as part of the FS Process. The No-Action alternative would be considered if remediation efforts cause substantial risk to human health or the environment during implementation or when the cost of remediation is excessive compared to the benefits of the risk reduction achieved.	Retain
Limited Action Response	Land-Use Controls (LUCs)	Fencing and other LUCs	Fencing or other LUCs may be important for security (prevent vandalism to wells and associated equipment). Fencing/signage does not reduce the mobility, toxicity, or volume of COCs/COECs; nor does fencing/signage prevent exposures to many ecological receptors. LUCs alone would be ineffective for preventing exposure to groundwater and are not a standalone technology for limiting exposure to groundwater at the Site. As a result, fencing and LUCs are not retained for further consideration.	Reject
	Institutional Controls (ICs)	Government controls, proprietary controls, enforcement tools, and informational tools to limit Groundwater Use	ICs are administrative responses that are implemented to limit human and, in some cases, ecological exposures. ICs achieve RAOs by limiting land or resource use/access, and providing information that helps modify or guide human behavior at locations where COC concentrations prevent unlimited use and unrestricted exposure. ICs are a viable option for the Ballard Site and are retained for further consideration.	Retain
	MNA	Monitored Natural Attenuation	MNA is a remedy designed specifically to observe the stabilization and reduction of a groundwater plume in situ without active remedial intervention in the plume. The treatment mechanism relies on natural attenuation process like sorption and chemical transformation. MNA is a viable option for the Ballard Site and is retained for further consideration.	Retain
Source Controls	Regrading/ Capping	See Upland Soil/Waste Rock Table 4-1	Source controls include actions that reduce or eliminate constituent migration to groundwater from known and potential source areas. Grading the existing waste rock and/or applying a cover system or capping is an alternative for limiting water infiltration and percolation through the waste rock. Source controls are retained for further consideration. These source control technologies will need to be coupled with an approach for managing the current COC plumes downgradient of the sources.	Retain
Containment	Vertical Barriers	Extraction Wells	Extraction wells would be comprised of pumping wells designed to create a hydraulic barrier or hydraulic control by intercepting the flow of impacted groundwater. Extracted groundwater likely would require treatment prior to disposal or reuse. Depending on the necessity and location, extraction wells could be used in the deeper aquifer (Wells Formation,) but likely would have limited use in the shallow aquifer associated with contaminated groundwater because of the shallow stratigraphy. Extraction wells are retained for further consideration.	Retain
		Extraction Trenches	An extraction trench is a viable option and would consist of an open or gravel backfilled trench which is keyed into an underlying clay layer. The extraction trench would be designed to create a hydraulic barrier by intercepting the flow of impacted groundwater similar to an extraction well barrier. Extracted groundwater would likely require treatment prior to disposal or reuse. Depending on the necessity and location, extraction trenches could be used in the shallow aquifer groundwater plume, but would not be technically implementable in the much deeper Wells aquifer.	Retain
		Injection Wells	An injection well would be similar to the extraction well option, except that water would be injected into the aquifer to form a hydraulic barrier by increasing the water level down gradient of the impacted portion of the aquifer. This option would require a large amount of clean water to be injected into the subsurface. Given the hydrogeological conditions in the underlying aquifers, injection wells would not be technically practical or implementable. As a result, injection wells have been eliminated from further consideration at the Site.	Reject

The treatment technologies and/or process options in the shaded cells have been eliminated from further evaluation in Section 5.

Table 4-6
Summary of Initial Groundwater Technology Screening
FEASIBILITY STUDY MEMORANDUM No.1
P4 Production LLC, Ballard Mine Site, Idaho

BALLARD MINE GROUNDWATER				
General Response Actions	**Treatment Technologies**	**Process Options Considered**	**Site Specific Considerations - Selection Rationale**	**Initial Screening Results**
Containment (cont.)	Vertical Barriers (cont.)	Cut-off (Slurry or Grout) Wall	Slurry walls usually are constructed by excavating materials to the required depth, and backfilling with a mixture of fine-grained soils and bentonite clay. Grout walls can be constructed in a similar manner, replacing the excavated material with cement or silica gel grout mixture. Grout walls typically are constructed by drilling overlapping large diameter borings and backfilling them with cement grout. Cut-off walls would be a potential remedy only for the shallow alluvial aquifer, and would be effective only if coupled with groundwater extraction from behind the wall. It is considered that a cut-off wall could be a possible enhancement to groundwater extraction in a unique situation, but not as a standalone or primary option. As a result, cut-off walls for contaminated groundwater have been <u>eliminated</u> from further evaluation.	Reject
Removal and Disposal	Removal	Pumping	Groundwater extraction is a viable option and would be accomplished by installing a sufficient number of wells to result in capture of the groundwater COC plume with the combined objectives of hydraulic containment and reducing COC concentrations over time. Extraction would be performed in conjunction with ex-situ treatment and some type of disposal, whether land application, discharge to a surface impoundment, or recycling/reuse as presented below.	Retain
	Disposal	Recycle/Reuse	Recycling of groundwater is a viable option and would be dependent on the water quality and quantity. Depending on the quality of the extracted groundwater and the water quality requirements for the receiving location, some degree of treatment may be required. Because the Ballard Mine is inactive, opportunities for recycling and reuse of the groundwater are limited and would only be short-term (e.g., dust control during remedial construction). This process option is retained for further consideration.	Retain
		Land Application	Land application would consist of applying discharged groundwater to an area using irrigation. The allowable quality and quantity applied would depend on land use, soil characteristics (e.g., attenuation potential), depth to groundwater, climatic conditions, and other factors. Land application could be a beneficial use if the water is used for irrigating crops. Some level of treatment would be needed if bioaccumulation in the cultivated crops is a concern, or infiltration to groundwater is an issue. Because groundwater recovery and treatment is not likely to vary much seasonally, land application may have to be coupled with seasonal storage or another alternative. This process option is retained for further consideration.	Retain
		Discharge to Surface Water	Discharge to surface water would be an effective method for disposal of treated groundwater from the Site. Due to elevated selenium concentrations in the Blackfoot River, additional requirements may be required to reduce the MDL of selenium being discharged. If no further degradation is a requirement, it is unlikely that anything but highly treated groundwater could be discharged to the Blackfoot River. This process option is retained for further consideration.	Retain
		Evaporation/ Infiltration Basin	Discharge to an evaporation/infiltration trench or basin would require treatment of the groundwater before it is discharged to an infiltration basin. Disposal solely by evaporation would not require additional treatment, but would only be feasible seasonally. A specially designed basin(s) would have to be constructed at or near the Site. This process option is retained for further consideration.	Retain
		POTW	Discharge to a POTW would require a discharge permit and approval by the POTW. The Site is not close to any municipality or other POTW. As a result, discharge to a POTW is <u>eliminated</u> from further consideration.	Reject
		Reinjection Wells	Following treatment, extracted groundwater could be reinjected directly into the aquifer using an injection well(s) to replace a portion of the extracted volume. The amount of reinjected water would be dependent upon hydrogeological conditions, water quality, and potentially on State of Idaho and Underground Injection Control (UIC) regulations. However, reinjection using wells is more difficult to implement and may be no more effective than an infiltration trench or basin, while typically being much more expensive to construct and maintain. As a result, reinjection is <u>eliminated</u> from further consideration for use at the Site.	Reject
Ex-Situ Treatment	Physical	Solid/ Water Separation	Separation consists of mechanical and gravity methods for bulk removal of suspended solids from groundwater. Considering that most of the Site groundwater constituents are in the dissolved phase, separation would not be sufficient as a "standalone" technology, but could be incorporated as a viable process option into the treatment train of a larger treatment system. For example, a clarifier is often a component of a chemical precipitation process.	Retain
		Filtration	Filtration is applicable for a wide range of solid sizes, but primarily is used for "polishing" the final effluent prior to discharge. Often filtration is used downstream of gross solid/water separation and likely that would be the most viable location for filtration in any treatment process that might be implemented for Site water treatment. Filtration would not be effective for dissolved constituents. Although filtration of some solids may be incorporated into an overall Site water treatment design, it would not be effective as a standalone technology for the dissolved constituents detected in Site groundwater.	Retain
		Adsorption	Adsorption uses various adsorbents to remove dissolved phase constituents from groundwater. Adsorption would be capable of removing selenium and arsenic to levels below cleanup criteria. The influent pH may need to be increased to improve the efficiency of this technology. This technology is a viable option and also can be used as a polishing step for the final treated effluent and, as such is retained for further consideration.	Retain

The treatment technologies and/or process options in the shaded cells have been eliminated from further evaluation in Section 5.

Table 4-6
Summary of Initial Groundwater Technology Screening
FEASIBILITY STUDY MEMORANDUM No.1
P4 Production LLC, Ballard Mine Site, Idaho

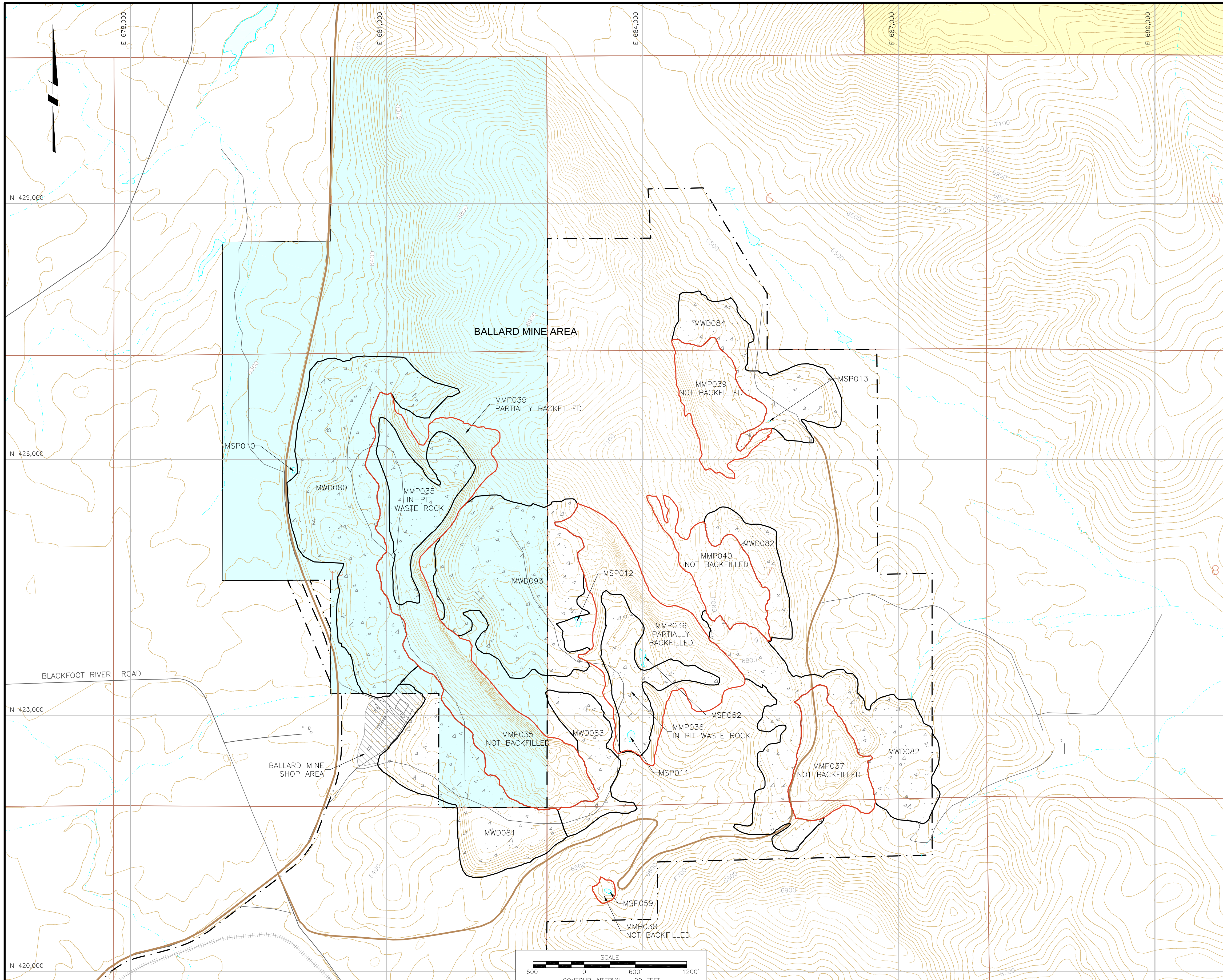
BALLARD MINE GROUNDWATER				
General Response Actions	**Treatment Technologies**	**Process Options Considered**	**Site Specific Considerations - Selection Rationale**	**Initial Screening Results**
Ex-Situ Treatment (cont.)	Physical (cont.)	Ion Exchange	Ion exchange is a process option in which cation and anion exchange resins are used to remove ions from water/wastewater. Due to the limited capacity of ion exchange resins, regeneration or replacement of the resin is required, thus the ion exchange process would result in waste materials which would require further handling and management. Ion exchange is a viable option for arsenic and selenium, possibly in combination with other technologies.	Retain
		Membrane Technologies (RO/ED/NF)	Membranes technologies include reverse osmosis (RO), electrodialysis/electrodialysis reversal (ED/EDR), and nanofiltration (NF). RO and NF are physical treatment processes in which pressurized water is passed through a semi-permeable membrane. ED is a very effective membrane process that employs an electric field to separate liquid influent into a concentrated waste stream and clean effluent. Membrane technologies are viable ex-situ process options and could be used to treat COCs/COECs found in Site groundwater and are retained for further consideration.	Retain
	Chemical	Solvent Extraction	Solvent extraction is the separation of constituents from a liquid by contact with another immiscible liquid. Solvent extraction is effective on organic constituents and some metals, but is not proven to be an effective treatment method for selenium. Therefore, solvent extraction is not a viable technology and is <u>eliminated</u> from further screening.	Reject
		Chemical Precipitation	Chemical precipitation is a treatment method in which dissolved metal ions and/or dissolved salts are precipitated in the form of insoluble salts. Chemical precipitation is a commonly used technology for removal of metals and is effective for selenium, arsenic and cadmium and is retained for further consideration.	Retain
		Oxidation/ Reduction	Chemical oxidation and reduction, such as use of ozonation, chlorination, hydrogen peroxide, and ultraviolet light, employs agents that raise or lower the oxidation states of COCs. Oxidation/reduction reactions have been demonstrated as a standalone process for treatment of organics in groundwater. In the case of inorganics, such as arsenic and selenium, oxidation/reduction may improve the separation characteristics and would be used with other technologies for treatment of Site COCs	Retain
	Thermal	Evaporation/ Distillation	Evaporation is a process in which water is heated to the boiling point. The water vapor is condensed to form condensate (distilled water) which is a clean product. Mechanical evaporation may be an applicable process option for COCs in conjunction with other technologies.	Retain
		Wet Air Oxidation	Wet air oxidation is a combustion process that occurs in the liquid phase by adding air at high temperatures and pressure. While the process is effective at destroying organic compounds, it is not considered effective for inorganics. Therefore, wet air oxidation is not a viable technology for COCs in Site groundwater and is <u>eliminated</u> from further screening.	Reject
	Biological	Biological	Biological treatment involves the transformation, degradation or fixation of contaminants by microorganisms. The most common form of biological treatment for metals and some non-metals, like selenium, is biological reduction using anaerobic bacteria followed by precipitation or absorption of the COC. This may be conducted in anaerobic wetlands, a pond, or a bioreactor, as examples. Bioreactor treatment can range from simple field systems to more complex treatment plants. P4 tested a bioreactor system for the treatment of dump seep water at the Site with favorable results for selenium, arsenic, cadmium and several other metals that would be a concern if the discharge was routed to surface water (P4, 2011). The system test consistently produced treated water that had selenium concentrations below the groundwater MCL (0.05 mg/L).	Retain
In-Situ Treatment	Physical	Mechanical Aeration	Mechanical aeration would involve injecting air into the subsurface, similar to that done as part of air sparging to oxidize COCs. Mechanical aeration would not be effective for treatment of selenium or the other Site COCs and therefore is <u>eliminated</u> from further consideration.	Reject
	Chemical	Chemical Injection (Oxidation /Hydrolysis)	Chemical injection is a viable option for the treatment of Site COCs/COECs in groundwater. The injected chemical agents, either oxidizing or reducing compounds, interact with the constituents in the groundwater plume to neutralize, precipitate, immobilize, fixate, or destroy the COCs. Issues associated with chemical injection include heterogeneity of subsurface sediments that result in areas that go untreated, production of undesirable by-products, and incomplete reactions. The primary treatment method for selenium and the other constituents would be in-situ reduction using a chemical such as calcium polysulfide. Such chemical reduction can have the benefit of developing a favorable environment for the growth of anaerobic bacteria resulting in long-term biological reduction treatment. The chemicals used for treatment may be injected throughout the aquifer to reduce the total contaminant mass in the plume or in zones as source control or to contain the plume migration as discussed below. This option is retained for further consideration.	Retain

The treatment technologies and/or process options in the shaded cells have been eliminated from further evaluation in Section 5.

Table 4-6
Summary of Initial Groundwater Technology Screening
FEASIBILITY STUDY MEMORANDUM No.1
P4 Production LLC, Ballard Mine Site, Idaho

BALLARD MINE GROUNDWATER				
General Response Actions	**Treatment Technologies**	**Process Options Considered**	**Site Specific Considerations - Selection Rationale**	**Initial Screening Results**
In-Situ Treatment (cont.)	Chemical	Permeable Reactive Barrier (PRB) / Chemical Injected Reductive Reaction Zone	These technologies are discussed together because both are closely related and have been applied in combination at several sites. Permeable reactive barriers (PRB) consist of reactive materials placed in a trench or cell in which the groundwater must pass through. Typically, the groundwater is flowing under its natural gradient thereby creating a passive treatment system. PRBs installed at P4's South Rasmussen Mine utilize limestone gravel, alfalfa, and wood chips to promote bacterial action have been very effective in reducing multiple constituents, including those considered COCs/COECs at Ballard.	Retain
	Thermal	Thermal Desorption	In-Situ Thermal Desorption (ISTD) uses thermal wells, along with heated extraction wells, to remediate COCs. Heat is applied using a high-temperature surface in contact with the groundwater and aquifer matrix, so that radiation and thermal conduction heat transfer are effective near the heated extraction wells. ISTD primarily has been used to treat organic contaminants. This technology has limited effectiveness for the Site inorganic COCs and is eliminated from further consideration.	Reject
	Biological	Biological	In-situ biological treatment of groundwater uses the same principles of ex-situ biological treatment. It consists of enhancing the biological transformation constituents by microorganisms to less mobile species. In-situ biological treatment may be facilitated by introducing a carbon source and nutrients to the treatment zone. Therefore, in-situ biodegradation is a viable technology for COCs detected in Site groundwater.	Retain

The treatment technologies and/or process options in the shaded cells have been eliminated from further evaluation in Section 5.



LEGEND:

- 7000 POST-MINE CONTOUR AND ELEVATION, FEET (APPROXIMATE)
- RIVER
- POND OR LAKE
- NATURAL DRAINAGE – PERENNIAL
- NATURAL DRAINAGE – INTERMITTENT
- HIGHWAY
- ROAD
- MONSANTO HAUL ROAD (ACTIVE & INACTIVE)
- RAILROAD
- MINE PIT LOCATION (APPROXIMATE WHERE COVERED BY BACKFILL)
- WASTE ROCK DUMP LOCATION (APPROXIMATE)
- WASTE ROCK DUMP LOCATION OR PIT BACKFILL (APPROXIMATE)
- P4 PRODUCTION PROPERTY BOUNDARY (APPROXIMATE)
- SECTION LINES
- A SECTION NUMBER
- BLM LANDS
- US NATIONAL FORESTS
- STATE LANDS
- OTHER PRIVATE LANDS

KEY:

MMP = MINE PIT
MWD = WASTE ROCK DUMP
MSP = POND

ISSUE	DESCRIPTION	TECH	ENG	DATE
0	ISSUED DRAFT FOR CLIENT REVIEW	CHF	LWM	

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DRAWING REFERENCE(S):
1. POST-MINE TOPOGRAPHY GENERATED FROM:
- USGS DIGITAL ELEVATION MODELS (DEM)-24K.
- SURVEY DATA FOR BALLARD MINE PROVIDED BY OLYMPUS AERIAL SURVEYS, INC. DATED: JUNE 2005.
- SURVEY DATA FOR HENRY MINE AREA PROVIDED BY OLYMPUS AERIAL SURVEYS, INC. DATED: NOVEMBER 2008.
- SURVEY DATA FOR ENOCH VALLEY MINE AREA PROVIDED BY P4 PRODUCTION DATED: DECEMBER 2007.
- US CENSUS BUREAU 2007 TIGER LINE DATA

PROJECTION:
STATE PLANE COORDINATE SYSTEM
ZONE:
IDAHO EAST
HORIZONTAL DATUM:
NAD27
VERTICAL DATUM:
NGVD29
UNITS:
U.S. FEET

DESIGNED BY	L MARTIN	09/17/13
DRAWN BY	C FOWLER	09/17/13
CHECKED BY	L MARTIN	09/17/13
APPROVED BY	C FOULK	09/17/13
PROJECT MANAGER	V DRAIN	
CLIENT APPROVAL		
CLIENT REFERENCE NO.		

P4 Production, LLC

PROJECT LOCATION
BALLARD MINE SITE

PROJECT
FEASIBILITY STUDY TECHNICAL MEMORANDUM #1

TITLE
BALLARD MINE AREA
DELINEATION MAP

MWH

DRAWING 4-1
REVISION 0
FILE NAME 10502806D001

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5 FINAL SCREENING OF REMEDIAL TECHNOLOGIES

This section further screens the potentially applicable remedial technologies and associated process options identified in Section 4.0 for anticipated effectiveness, potential implementability, and order of magnitude cost estimates.

The goal of this final technology-screening step is to further reduce the number of retained process options to a subset consisting of only the most viable technologies that ultimately will be used to develop remedial alternatives for the Site. Additional details regarding these evaluations are discussed below.

- **Effectiveness Evaluation**. The primary measure of effectiveness used in the final screening is the degree to which a remedial technology/process option would contribute to achievement of the RAOs for the Site. Other effectiveness criteria specified in Section 4.2.5.1 of the *RI/FS Guidance* include:

  ✓ The capacity to handle the estimated areas or volumes of media to be remediated;

  ✓ Potential impacts to human health and the environment during the construction and implementation phase; and

  ✓ The demonstrated reliability with respect to the COCs/COECs and conditions at the Site.

  Process options were also evaluated on the basis of effectiveness relative to other process options within the same technology type to reduce the process options to one or two for each technology.

- **Implementability Evaluation**. The technical and administrative feasibility of implementing retained technologies or process options is further considered during the final evaluation of the remaining technologies. The implementability evaluation follows *RI/FS Guidance,* which states:

  > "…technical implementability is used as an initial screen of technology types and process options to eliminate those that are clearly ineffective or unworkable at a site. Therefore, this subsequent, more detailed evaluation of process options places greater emphasis on the institutional aspects of implementability, such as the ability to obtain necessary permits for offsite actions, the availability of

treatment, storage, and disposal services (including capacity), and the availability of necessary equipment and skilled workers to implement the technology."

- **Cost Evaluation.** Cost analyses are performed based on EPA guidance documents, experience in costing similar projects, independent estimates, and engineering judgment. The costs of implementing process options relative to other options in the same technology type were estimated as high, moderate, and low for both capital costs and the operation and maintenance (O&M) costs. Where applicable, the volume/area estimates contained in Section 4.0 are considered in estimating the anticipated costs of each process option. In accordance with the *RI/FS Guidance*, those process options providing similar effectiveness at significantly higher relative costs are eliminated from further consideration in this final screening stage.

The remedial technologies and process options that are retained from this final screening step will be assembled into several comprehensive remedial alternatives for each of the impacted Site media in the second technical memorandum (Ballard FS Memo #2) as described below in Section 5.2. This iterative process allows the development of remedial alternatives to be streamlined by limiting the number of technologies for each medium requiring remediation.

5.1 MEDIA-SPECIFIC TECHNOLOGY SCREENING

A summary of the detailed technology screening performed for each of the Site media is included on the following tables:

- **Table 5-1** – Upland Soil/Waste Rock
- **Table 5-2** – Surface Water
- **Table 5-3** – Sediment/Riparian Soil
- **Table 5-4** – Groundwater

Additional information regarding the individual remedial technologies and more specific detail regarding the effectiveness, implementability, and cost criteria screening is presented in **Appendix B**.

Based on the screening presented in these tables the following technologies have been retained for each medium:

5.1.1 Upland Soils/Waste Rock

5.1.1.1 No-Action

- **No-Action** – Evaluation of the No-Action alternative is required by the NCP as a point of comparison with other alternatives. As a result, No-Action alternative is included for all of the media requiring remediation.

5.1.1.2 Limited Action Response

- **Institutional Controls** – Proprietary and governmental controls are effective at limiting access and direct human exposure to COCs in upland soil, associated vegetation, and waste rock on the Site. ICs are typically a component of an overall Site remedy.

- **Land Use Controls** – Fencing is effective at limiting access and direct exposure to COCs/COECs on the Site. Fencing is typically part of an overall Site remedy.

5.1.1.3 Containment

- **Multi-Layered Cap** – Multi-layer caps are effective for protection of groundwater and minimizing direct exposure and ingestion of all Site COCs/COECs.

- **Evapotranspirative (ET) Soil Cover** – ET caps are used to prevent future groundwater impacts and to minimize direct exposure and ingestion of Site COCs/COECs when applied with other ICs (e.g., fencing and deed restrictions).

- **Soil Cover Cap** – Soil cover caps would limit contaminant migration and exposure to gamma radiation.

- **Soil Grading** – Soil grading is retained as a component of an overall Site remedy that meets the RAOs.

5.1.1.4 Removal and Disposal

- **Conventional Excavation** – Conventional excavation is an ancillary activity to other treatment, disposal, or reuse options. Conventional excavation would be necessary in conjunction with On-Site Consolidation, or On-Site Disposal (i.e., backfilling of existing pits).

- **On-Site Disposal** – Consolidation and On-Site Disposal (i.e., backfilling of pit or pits) may be the most feasible method for remediating the large volumes of upland soil/waste rock.

5.1.2 Surface Water

5.1.2.1 No-Action

- **No-Action** – As discussed above, evaluation of the No-Action alternative is required by the NCP as a point of comparison with other alternatives.

5.1.2.2 Limited Action Response

- **Institutional Controls** – Proprietary and governmental controls effective at limiting access and direct human exposure to COCs in impacted surface water. ICs are typically a component of an overall Site remedy.

- **Land Use Controls** – Fencing is retained because it would effectively limit access and exposures to some receptors. Fencing typically is a component of an overall Site remedy.

5.1.2.3 Source Controls

- **Source Controls** – Source controls in the upland soil/waste rock are likely to be a critical component of an overall Site surface water remedy.

5.1.2.4 Containment

- **Retention Basins** – Retention basins are a standard BMP that can be used to help reduce the transport of COCs/COECs off-Site.

5.1.2.5 Removal and Disposal

- **Treated Discharge to Surface Water –** Treated discharge to surface water is retained because a NPDES permit could be obtainable considering that the volumes of treated discharges would be similar to current flows, and because COC/COEC concentrations in the treated discharge would be below current concentrations, risk levels and cleanup levels.

- **Evaporation/Infiltration Basins or Trench –** Evaporation/infiltration basins only would be considered for surface water if a NPDES permit could not be obtained to allow discharge back to Site drainages.

5.1.2.6 Ex-Situ Treatment

- **Solid/Water Separation –** Rejected as standalone treatment because a large portion of the surface water COCs/COECs are in the dissolved phase, but retained for possible use in conjunction with other treatment options.

- **Filtration –** Filtration is not retained as standalone treatment because most of the groundwater COCs/COECs are in the dissolved phase. However, filtration could be used in conjunction with other treatment options.

- **Membrane Technologies –** Membrane technologies are retained because they are highly effective for treating all of the Site COCs/COECs. However, the brine stream from this process would require additional treatment or management.

- **Chemical Precipitation –** Chemical precipitation is retained as a treatment technology for removal of metals and/or selenium. May require other ex-situ process options including reduction for selenium and separation/filtration to complete the treatment train, depending on the discharge requirements.

- **Oxidation/Reduction –** Not retained as a standalone treatment because it would not by itself reduce COC/COEC concentrations sufficiently. However, oxidation/reduction is retained as a treatment step because it may be necessary to reduce influent surface water for improved selenium removal efficiency in the chemical precipitation process.

- **Ex-Situ Biological** – Ex-situ biological treatment is retained because the technology was demonstrated at the Ballard Site.

5.1.2.7 In-Situ Treatment

- **In-Situ Biological** – In-situ biological treatment is retained because a passive treatment technology could be suitable for residual seep and spring treatment following source controls (e.g., waste rock capping).

5.1.3 Sediment/Riparian Soil

5.1.3.1 No-Action

- **No-Action** – As discussed above, evaluation of the No-Action alternative is required by the NCP as a point of comparison with other alternatives.

5.1.3.2 Limited Action Response

- **Institutional Controls** – Deed restrictions may be the most feasible option to reduce human health risks along the entire reach of the impacted intermittent drainages, and because some form of ICs likely will be a component of an overall Site remedy.
- **Land Use Controls** – Fencing may be a feasible option to reduce human health risks in the intermittent drainages, and could be a component of an overall Site remedy.
- **Monitored Natural Recovery (MNR)** – MNR may be a feasible option to reduce both human health and ecological risks with no man-made physical disruption in the intermittent drainages; and could be a component of an overall Site remedy. Because the majority of the Site drainages are under P4 control, and will be for the foreseeable future, human exposures to these areas are limited, and both human and ecological risks could be mitigated over time by MNR processes.

5.1.3.3 Removal and On-Site Disposal

- **Sediment traps/basins** – Sediment traps/basins could speed achievement of the RAOs, particularly if coupled with other technologies (e.g., MNR and/or ICs, source controls).
- **Removal and On-Site Disposal** – Removal and On-Site Disposal could be implemented and would meet the RAOs assuming source controls are implemented in the upland soil/waste rock.

5.1.4 Groundwater

5.1.4.1 No-Action

- **No-Action** – As discussed above, evaluation of the No-Action alternative is required by the NCP as a point of comparison with other alternatives.

5.1.4.2 Limited Action Response

- **Institutional Controls** – ICs are retained because they may be the most feasible option to reduce human health risks posed by groundwater and because some form of ICs likely will be a component of an overall Site remedy.

- **Monitored Natural Attenuation (MNA)** – Given Site conditions, MNA should be considered a viable technology for portions of or whole groundwater COC plumes at the Site pending further evaluation.

5.1.4.3 Source Controls

- **Source Controls –** Source controls (i.e., grading, cover system, etc.) in the upland soil/waste rock are likely to be a critical component of an overall groundwater remedy.

5.1.4.4 Containment

- **Extraction Wells (alluvial unit only) –** Use of extraction wells to form a complete hydraulic barrier for all alluvial plumes is not likely to be feasible. However, an extraction well system could be moderately effective and implementable as a barrier for select areas in the alluvial unit, especially where the depth to groundwater or depth to the bottom of COC contamination may be beyond the reach of a trench system. The extraction wells would need to be coupled with treatment and/or disposal options.

- **Extraction Trenches (alluvial unit only) –** Extraction trenches could be effective for intercepting shallow alluvial plumes. Installation could be relatively straightforward to implement in some areas. In other areas, depth to groundwater may be an impediment. The trenches would need to be coupled with treatment and/or disposal options.

5.1.4.5 Removal and Disposal

- **Pumping (Wells Formation only)** – Pumping, using extraction wells, is one of the only practicable removal technologies for plume remediation in the Wells Formation even though the effectiveness could be low. The Wells Formation aquifer is extensive and achieving sufficient drawdown could be difficult.

- **Evaporation/Infiltration Basin –** Implementable on-Site and could be used for reintroducing treated groundwater into the aquifer with a low to moderate cost.

5.1.4.6 Ex-Situ Treatment

- **Solid/Water Separation –** Solid/water separation is not retained as standalone treatment because it would not by itself reduce COC/COEC concentrations sufficiently, but is retained for possible use in conjunction with other treatment options.

- **Filtration –** Filtration is not retained as standalone treatment because most of the groundwater COCs/COECs are in the dissolved phase. However, filtration could be used in conjunction with other treatment options.

- **Membrane Technology –** Highly effective for treating all of the Site COCs/COECs. However, the brine stream from this process would require additional treatment or management.

- **Chemical Precipitation –** Retained as a treatment technology for removal of metals and/or selenium. Likely would require other ex-situ process options (e.g., separation/filtration and selenate reduction) to complete the treatment train, depending on discharge requirements. Generates a sludge that would require management and disposal.

- **Oxidation/Reduction –** Oxidation/Reduction is not retained as a standalone treatment because it would not by itself reduce COC/COEC concentrations sufficiently. However, oxidation/reduction could be useful as a treatment step (component) to reduce selenate in influent groundwater for improved selenium removal efficiency in the chemical precipitation process.

- **Ex-Situ Biological –** Biological treatment is retained because the technology was demonstrated at the Ballard Site.

5.1.4.7 In-Situ Treatment

- **Chemical Injection (alluvial unit only) –** Likely to be effective for remediating Site COCs/COECs in groundwater. Implementation in the alluvial unit is straightforward; whereas, implementation in the Wells Formation is would be complex.

- **Reactive Barriers (alluvial unit only) –** PRBs have been used with success to treat groundwater contaminated with inorganic COCs/COECs. Effectiveness and implementability in the alluvial unit is likely to be high.

- **In-Situ Biological (alluvial unit only) –** In-situ biological reduction would be effective for remediating Site COCs/COECs in groundwater. Implementation in the alluvial unit is straightforward.

5.2 BALLARD FEASIBILITY STUDY MEMORANDUM #2

Following A/T review and approval of this Ballard FS Memo #1 document, the Ballard FS Memo #2 will be prepared to:

- Assemble remedial alternatives for each of the impacted Site media by combining the remedial technologies and process options that were retained following the final screening presented in this section.
- Screen the assembled alternatives using a qualitative process to determine overall effectiveness, implementability, and cost. The purpose of alternative screening is to reduce the number of remedial alternatives retained for detailed analysis.
- Perform a detailed analysis of the retained remedial alternatives using the seven evaluation criteria described in the *RI/FS Guidance*. These criteria were developed to address statutory requirements and considerations for RAs in accordance with the NCP and additional technical and policy considerations that have proven to be important for selecting among remedial alternatives.
- Perform a comparative analysis to identify the key tradeoffs between the remedial alternatives.

Table 5-1
Upland Soil/Waste Rock Remediation Technology Screening Table
Feasibility Study Technical Memorandum #1
P4 Production LLC, Ballard Mine, Idaho

Process Option	Effectiveness	Implementability	Cost	Site-Specific Considerations	Applicability within the Site	Decision Rationale	Detailed Screening Results
No Action							
No Action See § B.1.1	Low	High	Low (no additional) capital costs; No O&M costs	The No-Action alternative is not appropriate in the upland soil/waste rock where there are unacceptable risks.	The No-Action alternative is only applicable to areas within the Site that meet the RAOs.	Evaluation of the No-Action alternative is required by the NCP as a point of comparison with other alternatives.	Retain
Limited Action Response							
Institutional Controls							
Proprietary Controls and Governmental Controls See § B.1.2	High when applied with other remedial technologies.	Moderate	Low capital; Low O&M	There are no Site-specific considerations that would inhibit establishing proprietary and governmental controls other than obtaining the cooperation of the adjacent landowners.	Proprietary controls and governmental controls are potentially applicable to impacted areas of upland soil/waste rock.	Proprietary and governmental controls are effective at limiting access and direct human exposure to COCs in upland soil, associated vegetation, and waste rock on the Site. ICs are typically a component of a selected remedial alternative.	Retain
Land Use Controls							
Fencing See § B.1.2	High when applied with other remedial technologies.	High	Low capital; Low O&M	Fencing is already in place around portions of the Site perimeter, although some fence improvements and additional fencing may be required.	Fencing is applicable to upland soil/waste rock areas that have unacceptable risks.	Fencing is effective at limiting access and direct exposure to COCs/COECs on the Site. Fencing is typically part of a selected remedial alternative.	Retain
Containment							
Cover Systems							
Multi-Layered Cap See § B.1.3.1	High	Moderate	High capital; Moderate O&M	Access and vegetation restrictions to limit cap intrusion and resulting exposure to underlying waste rock/contaminated soil would also be required.	Multi-layer caps are applicable to areas with potential groundwater impacts (i.e., West Ballard Pit) from Site COCs. May include multiple designs based upon mobility and risk posed by the specific COCs/COECs being capped.	Multi-layer caps are effective for protection of groundwater and minimizing direct exposure and ingestion of all Site COCs/COECs when implemented in conjunction with ICs (e.g., fencing and deed restrictions).	Retain
Evapotranspirative (ET) Soil Cover See § B.1.3.1	High	High	Moderate to High capital (with on-Site soil source); Low O&M	ET cover systems are used extensively in the Phosphate mining region of SE Idaho. Site Specific design would be based on performance criteria that would include eliminating future groundwater impacts and direct exposure of Site COCs/COECs. Infiltration modeling would be necessary to establish the overall thickness of an ET cover system. An ET cap would be used with other ICs to limit exposure to underlying wastes/contaminated soil and potential intrusions to the cap.	ET caps are applicable to all areas of the Site with waste rock.	ET caps are used in the region to prevent future groundwater impacts and to minimize direct exposure and ingestion of Site COCs/COECs when applied with other ICs (e.g., fencing and deed restrictions).	Retain
Soil Cover Cap See § B.2.3.1	High, but only for gamma protection.	High	Low capital (with on-Site soil source); Low O&M	Soil cover caps could be considered for areas on Site with gamma radiation and for wastes with non-leachable levels of COCs.	Soil cover caps are potentially applicable to areas with gamma levels posing risk, but may not be appropriate for areas with upland soil containing leachable metals.	Soil cover caps may not prevent migration of inorganic COCs to groundwater via infiltration. Due to the presence of leachable inorganics in the waste rock dumps, multi-layer and ET cover systems may out-perform a pure soil cover for achieving the RAOs.	Retain
Surface Control							
Soil Grading See § B.1.3.2	High when combined with other remedial technologies.	High	Low capital; Low O&M	The topography of the Site is conducive to using site-wide grading to divert a portion of surface water flow away from the impacted upland soil/waste rock.	Soil grading is applicable to all areas of impacted upland soil/waste rock.	Soil grading is retained as a component of an overall remedy that meets the RAOs.	Retain
Removal and Disposal							
Removal							
Conventional Excavation See § B.1.4.1	High	High	High capital; No O&M	The upland soil/waste rock areas are conducive to using conventional excavation equipment to remove the impacted materials.	Conventional excavation is applicable to areas of the Site containing impacted upland soil/waste rock and associated vegetation.	Conventional excavation is an ancillary activity to other treatment, disposal, or reuse options. Conventional excavation would be necessary in conjunction with on-Site consolidation, or disposal (i.e., backfilling of existing pits).	Retain
Disposal							
On-Site Disposal See § B.1.4.2	High	High	High to moderate capital; Low to Moderate O&M	The layout of the Site (e.g., existing mine pits) is conducive to the consolidation and capping the potentially large volumes of excavated wastes.	On-Site disposal is applicable to areas of the Site containing impacted upland soil/waste rock.	Consolidation and on-Site disposal may be the most feasible method for remediating the large volumes of upland soil/waste rock.	Retain

Table 5-2
Surface Water Remediation Technology Screening Table
Feasibility Study Technical Memorandum #1

Process Option	Effectiveness	Implementability	Cost	Site-Specific Considerations	Applicability within the Site	Decision Rationale	Detailed Screening Results
No Action							
No Action See § B.3.1	Low	High	Low (no additional) capital; No O&M	The No-Action alternative is not appropriate where COC/COEC concentrations exceed the surface water ARARs.	The No-Action alternative is potentially applicable where COC/COEC concentrations do not exceed the surface water ARARs.	Although the No-Action alternative does not reduce risks or meet chemical-specific ARARs in the Site surface water, it is retained as point of comparison as required by the NCP.	Retain
Limited Action Response							
Proprietary Controls and Governmental Controls See § B.3.2.1	High, especially when combined with other remedial technologies.	Moderate	Low capital; Low O&M	There are no Site-specific considerations that would inhibit establishing proprietary and governmental controls other than obtaining the cooperation of the adjacent landowners.	Proprietary and governmental controls are potentially applicable to all impacted areas of impacted Site surface water.	Proprietary and governmental controls are retained because they would be effective at limiting access and direct human exposure to COCs in the impacted surface water. ICs are typically a component of a selected remedial alternative.	Retain
Land Use Controls - Fencing See § B.3.2.1	High when combined with other remedial technologies.	High	Low capital; Low O&M	Requires the cooperation of the affected private landowners, and the perceived aesthetic impacts of a fence.	Fencing is applicable to all areas of impacted surface water that have unacceptable risks.	Fencing is retained because it would effectively limit access and exposures to some receptors. Fencing typically is a component of a selected remedial alternative.	Retain
Source Controls							
Source Controls See § B.3.3	Moderate to High	Low to High	Moderate to High capital; Low to Moderate O&M	Relies on source controls (i.e., grading, cover systems, etc.) in the upland soil/waste rock (see Table 5-1).	Sources of SW contamination in the upland soil/waste rock (see Table 5-1).	Source controls in the upland soil/waste rock are likely to be a critical component of an overall SW remedy.	Retain
Containment							
Sediment Control Basins							
Retention Basins See § B.3.4.1	Moderate	High	Low capital; Low O&M	Retaining contaminated surface water in retention basins may result in COCs/COECs being transferred to sediments and groundwater.	Retention basins are applicable to all areas where contaminated surface water is known or expected to flow off Site.	Retention basins are a standard BMP that will likely be needed during remedial construction, and to help reduce the transport of COCs/COECs off Site.	Retain
Wetlands See § B.3.4.2	Moderate	Low	Low capital; Low O&M	Site drainages are dry for much of the year and are not likely to support wetlands vegetation.	Surface drainages, and seep and spring locations throughout the Site.	Not retained as a containment option because wetland vegetation would have low survivability without a source of water besides storm water and runoff. Wetlands may be more applicable for treatment of the perennial seeps and springs.	Reject
Removal and Disposal							
Disposal							
Land Application See § B.3.5.1	Low	Low to Moderate	Low capital; Moderate O&M	A large tract of land with sufficient depth to groundwater may not be available. Cross-media transfer of COCs/COECs (e.g., from the water to culturally significant plants) could result in transfer of risks. Cold weather would complicate land application in the winter.	Land application could be applicable to all surface water that is removed and treated.	There are a large number of uncertain factors in applying the technology, such as locating an appropriate tract of land and media transfer of COCs/COECs. Other technologies that also require some treatment have lower cost and more certainty.	Reject
Treated Discharge to Surface Water See § B.3.5.2	High	High	Low to moderate capital; Low O&M	Obtaining NPDES permits for drainages that flow to the Blackfoot River could be difficult. The treated discharge in this case would result in a reduced selenium loading in the Blackfoot River.	Could be applicable to all surface water that is removed and treated.	Treated discharge to surface water is retained because a NPDES permit could be obtainable considering that the volumes of treated discharges would be similar to current flows, and because COC/COEC concentrations in the treated discharge would be below current concentrations, risk levels and ARARs.	Retain
Evaporation/Infiltration Basins or Trench See § B.3.5.3	Moderate to High	Moderate	Moderate capital, Low O&M	Disposal of collected surface water via an infiltration basin would require identifying an area with suitable permeability. Disposal via an evaporation basin would only be feasible during the warm summer months. Infiltration of Site surface water to groundwater would reduce flows in the associated watershed. The seasonal variability of Site surface water flow may make temporary storage of water necessary.	Could be applicable to all surface water that is removed and treated.	Evaporation/infiltration basins only would be considered for surface water if a NPDES permit could not be obtained to allow discharge back to Site drainages.	Retain

Table 5-2
Surface Water Remediation Technology Screening Table
Feasibility Study Technical Memorandum #1

Process Option	Effectiveness	Implementability	Cost	Site-Specific Considerations	Applicability within the Site	Decision Rationale	Detailed Screening Results
Ex-Situ Treatment							
Physical Processes							
Solid/Water Separation See § B.3.6.1	High if used in conjunction with other treatment technologies that precipitate dissolved COCs.	High	Moderate capital; Moderate O&M	Separation is not sufficient as a standalone treatment technology because a large portion of the surface water COCs are in the dissolved phase.	If used as a component of an overall treatment system, separation would be applicable to all Site surface water that requires treatment.	Rejected as standalone treatment because a large portion of the surface water COCs/COECs are in the dissolved phase, but retained for possible use in conjunction with other treatment options.	Retain
Filtration See § B.3.6.1	High if used in conjunction with other treatment technologies that precipitate dissolved COCs/COECs.	High	Moderate capital; Moderate O&M	Filtration is not sufficient as a standalone treatment technology because a large portion of the surface water COCs/COECs are in the dissolved phase.	If used as a component of an overall treatment system, filtration would be applicable to all Site surface water that requires treatment.	Filtration is not retained as standalone treatment because a large portion of the surface water COCs are in the dissolved phase. However, filtration could be used in conjunction with other treatment options.	Retain
Adsorption See § B.3.6.1	High for select COCs.	High	Moderate to High capital; High O&M	The treatment train may be complex with multiple types of absorption media and upfront chemical reduction to address all the Site COCs/COECs.	All areas where surface water is collected and requires treatment for disposal.	Other technologies considered will likely provide the required level of treatment. However, adsorption could be useful as a polishing step when combined with other treatment technologies.	Reject
Ion Exchange See § B.3.6.1	High	Moderate to High.	Moderate to High capital; Moderate to High O&M	Competing ions could reduce effectiveness (e.g., selenate and sulfate). Sulfate would be exchanged for chloride or hydroxyl ions, so TDS would only be marginally reduced.	All areas where surface water is collected and requires treatment for disposal.	Brine stream from ion exchange process would require additional treatment. More expensive than equally effective and implementable ex-situ water treatment technologies.	Reject
Membrane Tech. See § B.3.6.1	High	High.	High capital; High O&M	Selection of the specific membrane technology may warrant an engineering study to optimize the selection.	All areas where surface water is collected and requires treatment for disposal.	Membrane technologies are retained because they are highly effective for treating all of the Site COCs/COECs. However, the brine stream from this process would require additional treatment or management.	Retain
Chemical Processes							
Chemical Precipitation See § B.3.6.2	High	High	Moderate capital; High O&M	Because selenium in surface water at the Site is selenate, it may be necessary to electrochemically reduce the influent surface water to produce selenite for improved selenium removal efficiency in the chemical precipitation process.	All areas where surface water is collected and requires treatment for disposal.	Chemical precipitation is retained as a treatment technology for removal of metals and/or selenium. Likely would require other ex-situ process options including reduction for selenium (discussed below) and separation/filtration to complete the treatment train, depending on the discharge requirements.	Retain
Oxidation/Reduction See § B.3.6.2	High when considered in conjunction with other technologies.	High	Moderate capital; High O&M	Because selenium in surface water at the Site is selenate, it may be necessary to electrochemically reduce the influent surface water to produce selenite for improved selenium removal efficiency in the chemical precipitation process.	All areas where surface water is collected and requires treatment for disposal.	Not retained as a standalone treatment because it would not by itself reduce COC concentrations sufficiently. However, oxidation/reduction is retained as a treatment step (component) because it may be necessary to reduce influent surface water for improved selenium removal efficiency in the chemical precipitation process.	Retain
Thermal Processes							
Thermal Evaporation (Distillation) See § B.3.6.3	High	Moderate	Very high capital; High O&M	May require construction of equalization basins to store water prior to treatment.	All areas where surface water is collected and requires treatment for disposal.	Thermal evaporation/distillation is not retained due to very high capital and O&M costs compared to other equally effective technologies.	Reject
Biological Processes							
Ex-Situ Biological See § B.3.6.4	High	High	Low to moderate capital, Moderate O&M	Winter temperatures can reduce treatment efficiency.	All areas where surface water is collected and requires treatment for disposal.	Ex-situ biological treatment is retained because the technology was demonstrated at the Ballard Site.	Retain
In-Situ Treatment							
Biological Processes							
In-Situ Biological See § B.3.7.1	Moderate	High	Low to moderate capital; Low O&M	Winter temperatures can reduce treatment efficiency.	Site seeps and springs.	In-situ biological treatment is retained because a passive treatment technology could be suitable for residual seep and spring treatment following source controls (e.g., waste rock capping).	Retain

Notes:
The treatment technologies and/or process options in the blue shaded cells have been eliminated from further evaluation in the development of alternatives.

Table 5-3
Sediments/Riparian Soil Remediation Technology Screening Table
Feasibility Study Technical Memorandum #1
P4 Production LLC, Ballard Mine, Idaho

Process Option	Effectiveness	Implementability	Cost	Site-Specific Considerations	Applicability within the Site	Decision Rationale	Detailed Screening Results
No Action							
No Action See § B.4.1	Low	High	Low (no additional) capital costs; No O&M costs	The No-Action alternative is not appropriate in the Site drainages where there are unacceptable risks.	The No-Action alternative is only applicable to areas of the Site drainages that meet RAOs.	Evaluation of the No-Action alternative is required by the NCP as a point of comparison with other alternatives.	Retain
Limited Action Response							
Institutional Controls							
Proprietary Controls and Governmental Controls See § B.1.2	Moderate	High	Low capital; Low O&M	There are no Site-specific considerations that would inhibit establishing proprietary controls other than obtaining the cooperation of the private landowners.	Proprietary controls and government controls are potentially applicable to the entire reach of the impacted intermittent drainages.	ICs are retained because they may be the most feasible option to reduce human health risks posed by the impacted intermittent drainages.	Retain
Land Use Controls							
Fencing See § B.4.2.1	Moderate	High	Low capital; Low O&M	Site-specific considerations for constructing a fence include obtaining the cooperation of the affected private landowners, and the perceived aesthetic impacts of a fence.	Fencing could be applicable to the entire reach of the impacted intermittent drainages.	Fencing may be a feasible option to reduce human health risks in the intermittent drainages, and could be a component of an overall Site remedy.	Retain
Monitored Natural Recovery (MNR)							
Monitored Natural Recovery (MNR) See § B.4.2.2	High given sufficient time for the natural recovery processes to occur.	High	Low capital; Low O&M	Limited Site-specific data are available to understand the dominant MNR processes (e.g., rates of sedimentation and erosion), and to establish a remedial timeframe.	MNR could be applicable to the entire reach of the impacted intermittent drainages. Alternatively, MNR could be paired with other remedial technologies where an active technology (e.g., removal and on-Site disposal) is implemented in the more highly contaminated reaches near the waste rock piles and MNR is implemented in the lesser-contaminated reaches of the intermittent drainages.	MNR may be a feasible option to reduce both human health and ecological risks with no physical disruption in the intermittent drainages. Because the majority of the Site drainages are under P4 control, and will be for the foreseeable future, human exposures to these areas are limited, and both human and ecological risks could be mitigated over time by MNR processes.	Retain
Removal and On-Site Disposal							
Removal and on-Site Disposal See § B.4.3.1	High	Moderate to High	Moderate to High capital; Low O&M	Site terrain is conducive to using conventional excavation equipment. Excavated sediment/riparian soil would add a relatively insignificant volume to the upland soils/mine waste that requires remediation. Excavation as a remedial option likely would be limited to the more highly contaminated areas of the intermittent drainages near the mine site coupled with other non-invasive alternatives in the less contaminated downstream reaches.	Removal and on-Site disposal would be considered for the most contaminated areas near the mine waste rock piles and this material would be consolidated with the waste rock and upland soils during remediation.	Removal and On-Site Disposal could be implemented and would meet RAOs assuming source controls are implemented in the upland soil/waste rock.	Retain
Sediment Traps/Basins See § B.4.3.2	Moderate	High	Low capital; Low to Moderate O&M	The relatively small size of the intermittent drainages (both stream flows and channel widths) is conducive to the construction and O&M of sediment traps/basins. Traps/basins would need to be coupled with ICs to prevent access and exposures. The need to properly handle and dispose of collected sediments could compromise the relative ease of implementation.	Sediment traps/basins could be applicable to the entire reach of the contaminated intermittent drainages. Alternately, sediment traps/basins could be located in the more highly contaminated upper reaches of the drainages to help accelerate MNR processes.	Sediment traps/basins could speed achievement of RAOs, particularly if coupled with other technologies (e.g., MNR and/or ICs).	Retain
In-Situ and Ex-Situ Treatment							
Stabilization/ Solidification (S/S) See § B.4.4	Moderate	In-Situ: Moderate Ex-Situ: High	In-Situ: High capital; Low O&M Ex-Situ: Very high capital; Low O&M	Site terrain and nature of the sediment/riparian soil likely is conducive to both in-situ and ex-situ S/S. S/S is typically used to treat highly contaminated soils and/or to reduce the leachability of characteristically hazardous waste. COC/COEC concentrations in the Site sediment/riparian soil are relatively low compared with other sites where S/S has been used.	In-situ or ex-situ S/S likely only would be considered for the most contaminated areas near the mine waste rock piles.	S/S does not provide any advantages over the removal/on-Site disposal technology. S/S likely is not a cost effective remedial strategy considering the relatively low COC/COEC concentrations in the sediment/riparian soil in the intermittent drainages at the Site.	Reject

Notes:
The treatment technologies and/or process options in the brown shaded cells have been eliminated from further evaluation in the development of alternative

Table 5-4
Groundwater Remediation Technology Screening Table
Feasibility Study Technical Memorandum #1
P4 Production LLC, Ballard Mine, Idaho

Process Option	Hydrogeologic Unit	Effectiveness	Implementability	Cost	Site-Specific Considerations	Applicability within the Site	Decision Rationale	Detailed Screening Results
No Action								
No Action See § B.5.1	Both	Low	High	Low capital; No O&M	The No-Action alternative is not appropriate where there are unacceptable risks.	The No-Action alternative is only applicable to areas of the Ballard Site that meet the RAOs.	Evaluation of the No-Action alternative is required by the NCP as a point of comparison with other alternatives.	Retain
Limited Action Response								
Institutional Controls								
Governmental and Proprietary Controls See § B.5.2.1	Both	Moderate	High	Low capital; Low O&M	There are no site-specific considerations that would inhibit establishing ICs other than obtaining the cooperation of the landowners.	ICs could be applicable to all areas where COC concentrations in GW exceed the ARARs.	ICs are retained because they may be the most feasible option to reduce human health risks posed by GW.	Retain
Monitored Natural Attenuation								
Monitored Natural Attenuation See § B.5.2.2	Both	Moderate	High	Moderate capital; Low O&M	Limited Site-specific data are available to understand the dominant MNA processes (e.g., sorption), and to establish a remedial timeframe. Data supporting the Wells Formation (Fm) attenuation capacity is present in the region and could be correlated to Site conditions.	Slow rates of plume migration and relatively static COC concentrations in the Site GW suggest that MNA could be effective in portions or all of the Site.	Given Site conditions, MNA should be considered a viable technology for COC plumes at the Site.	Retain
Source Controls								
Source Controls See § B.5.3	Both	High	Moderate to High	Low to high capital; Low to moderate O&M	Relies on source controls (i.e., grading, cover systems, etc.) in the upland soil/waste rock (see Table 5-1).	Sources of GW contamination in the upland soil/waste rock (see Table 5-1).	Source controls in the upland soil/waste rock are likely to be a critical component of an overall GW remedy.	Retain
Containment								
Vertical Barriers								
Extraction Wells See § B.5.4.1	Alluvial	Moderate to High	Moderate	High capital; High O&M	The hydrogeology and depth to contaminated GW in the alluvial unit and Wells Fm are key considerations for the extraction well technology.	Extraction wells are applicable to all areas where ARARs are exceeded in the alluvial unit and Wells Fm GW. However, it may be more feasible to limit the technology to areas where the hydrogeology is more conducive to GW extraction and hydraulic containment.	Use of extraction wells to form a complete hydraulic barrier for all alluvial plumes is not likely to be feasible. However, an extraction well system could be moderately effective and implementable as a barrier for selected areas in the alluvial unit, especially where the depth to GW or depth to the bottom of COC contamination may be beyond the reach of a trench system.	Retain
	Wells Fm	Low to Moderate	Low	High capital; High O&M			Effectiveness as a barrier in the Wells Fm. may be difficult to demonstrate. The cost for extraction and monitoring wells would be very high, along with the cost of managing and treating a large volume of extracted GW.	Reject
Extraction Trenches See § B.5.4.1	Alluvial	High	High	Moderate capital; Moderate O&M	The depth to contaminated GW in the alluvial unit is generally within the depth that extraction trenches can feasibly be excavated.	Extraction trenches are applicable to all areas where GW contamination is within the reach of a trench system.	Extraction trenches could be effective for intercepting shallow alluvial plumes. Installation could be relatively straightforward to implement in some areas. In other areas, depth to GW may be an impediment. The trenches would need to be coupled with treatment and/or disposal options.	Retain
	Wells Fm	Low	Low	High capital; Moderate O&M	It would be difficult or impossible to install a trench deep enough to intercept the contaminated GW in the Wells Fm.	Extraction trenches are not applicable to the contaminated GW in the Wells Fm due to the depth to GW.	It would be difficult or impossible to install a trench deep enough to intercept the contaminated GW in the Wells Fm.	Reject
Removal and Disposal								
Removal								
Pumping See § B.5.5.1	Alluvial	Moderate	Moderate	High capital; High O&M	The hydrogeology and depth to contaminated GW in the alluvial unit and Wells Fm are key considerations for the removal technology.	Extraction wells are applicable to all areas where ARARs are exceeded in the alluvial unit and Wells Fm GW. In the Wells Fm, it may be more feasible to limit the technology to locations near the source area.	Would likely have limited effectiveness in the alluvial unit or require a long remediation timeframe with high costs including ex-situ treatment. In-situ treatment would be less expensive and have similar effectiveness.	Reject
	Wells Fm	Low to High	Low to Moderate	High capital; High O&M			Pumping of extraction wells is one of the only practicable removal technologies for plume remediation in the Wells Fm even though the effectiveness could be low. The Wells Fm aquifer is extensive and achieving sufficient drawdown could be difficult.	Retain

Table 5-4
Groundwater Remediation Technology Screening Table
Feasibility Study Technical Memorandum #1
P4 Production LLC, Ballard Mine, Idaho

Process Option	Hydrogeologic Unit	Effectiveness	Implementability	Cost	Site-Specific Considerations	Applicability within the Site	Decision Rationale	Detailed Screening Results
Disposal								
Recycle/Reuse See § B.5.5.2	Both	Low	Low	Low capital; Low O&M	A long-term, year-round use of the treated GW has not been identified.	Recycling/reuse would be applicable to all extracted GW.	Demand for water for reuse during mine reclamation or at nearby mines is likely not sufficient to consume the volume. Likewise, crop irrigation is a seasonal demand and likely not sufficient to consume the volume of produced water.	Reject
Land Application See § B.5.5.2	Both	Low to High	Low to Moderate	Low capital; Moderate O&M	A large tract of land with sufficient depth to GW may not be available. Cross-media transfer of COCs to culturally significant plants could result in transfer of risks. Cold weather would complicate land application in the winter.	Land application could be applicable to all GW that is removed and treated.	May be viable for disposal of small or seasonal volumes of water; likely not applicable for large volumes of recovered GW. In addition, GW recovery rates would be relatively consistent throughout the year complicating disposal during the cold winter months.	Reject
Surface Water Discharge See § B.5.5.2	Both	High	Low	Low to moderate capital; Low O&M	Obtaining NPDES permits for discharge to the Blackfoot River could be difficult or overly stringent. Direct discharge to the Blackfoot Reservoir would be technically challenging.	Could be applicable to all GW that is removed and treated.	Not retained due to the anticipated stringent requirements to obtain an NPDES permit (for discharge to the Blackfoot River), and technical issues that direct discharge to the Blackfoot Reservoir would involve (long pipeline crossing property with varying ownership).	Reject
Evaporation/Infiltration Basin See § B.5.5.2	Both	Moderate to High	Moderate	Moderate capital; Low O&M	Disposal of treated GW via an infiltration basin is dependent on identifying an area with suitable permeability. Disposal via an evaporation basin would only be feasible during the warm summer months.	Could be applicable to all GW that is removed and treated.	Could be used for reintroducing clean GW into the aquifer. Has a low to moderate cost.	Retain
Ex-Situ Treatment								
Physical Processes								
Solid/Water Separation See § B.5.6.1	Both	High if used in conjunction with other treatment technologies that precipitate dissolved COCs	High	Moderate capital; Moderate O&M	Separation is not sufficient as a standalone treatment technology because most of the GW COCs are in the dissolved phase.	If used as a component of an overall treatment system, separation would be applicable to all Site GW that requires treatment.	Rejected as standalone treatment because it would not by itself reduce COC concentrations sufficiently, but retained for possible use in conjunction with other treatment options.	Retain
Filtration See § B.5.6.1	Both	High if used in conjunction with other treatment technologies that precipitate dissolved COCs	High	Moderate capital; Moderate O&M	Filtration is not sufficient as a standalone treatment technology because most of the GW COCs are in the dissolved phase.	If used as a component of an overall treatment system, filtration would be applicable to all Site GW that requires treatment.	Filtration is not retained as standalone treatment because most of the GW COCs are in the dissolved phase. However, filtration could be used in conjunction with other treatment options.	Retain
Adsorption See § B.5.6.1	Both	High for select COCs	High	Moderate to High capital; High O&M	Treatment train may be complex to address all the Site COCs. Other ions in the influent would have an effect on treatment efficiency and would need to be evaluated. May be more applicable to lower flow rates.	All areas where GW is collected and requires treatment for disposal.	Other technologies considered will likely provide the required level of treatment. However, adsorption could be useful as a polishing step when combined with other treatment technologies.	Reject
Ion Exchange See § B.5.6.1	Both	Moderate to High	High	Moderate to High capital; Moderate to High O&M	Ion exchange is adaptable to most Site flow rates to be treated, but may be more applicable to lower flow rates. Ions in the influent would have an effect on treatment efficiently and would need to be evaluated during treatability testing.	All areas where GW is collected and requires treatment for disposal.	Brine stream from ion exchange process would require additional treatment. More expensive than equally effective and implementable ex-situ water treatment technologies. Membrane technologies that are discussed below provide a higher and more reliable level of treatment.	Reject
Membrane Technology See § B.5.6.1	Both	High	High	High capital; High O&M	Membrane technology is adaptable to the anticipated flow volumes. Suitable to treat all ions in the Site GW.	All areas where GW is collected and requires treatment for disposal.	Highly effective for treating all of the Site COCs. However, the brine stream from this process would require additional treatment or management.	Retain

Table 5-4
Groundwater Remediation Technology Screening Table
Feasibility Study Technical Memorandum #1
P4 Production LLC, Ballard Mine, Idaho

Process Option	Hydrogeologic Unit	Effectiveness	Implementability	Cost	Site-Specific Considerations	Applicability within the Site	Decision Rationale	Detailed Screening Results
Chemical Processes								
Chemical Precipitation See § B.5.6.2	Both	High	High	Moderate capital; High O&M	Effectiveness for selenium requires successful reduction of Site selenate to selenite (the following technology), which can be difficult with sulfate present.	All areas where GW is collected and requires treatment for disposal.	Retained as a treatment technology for removal of metals and/or selenium. Likely would require other ex-situ process options (e.g., separation/filtration and selenate reduction) to complete the treatment train, depending on discharge requirements. Generates a sludge that would require management and disposal.	Retain
Oxidation/Reduction See § B.5.6.2	Both	High when considered in conjunction with other technologies	High	Moderate capital; High O&M	May be a necessary technology to reduce the influent GW for improved selenium removal efficiency in the chemical precipitation process.	All areas where GW is collected and requires treatment for disposal.	Not retained as a standalone treatment because it would not by itself reduce COC concentrations sufficiently. However, oxidation/reduction could be useful as a treatment step (component) to reduce selenate in influent GW for improved selenium removal efficiency in the chemical precipitation process.	Retain
Thermal Processes								
Thermal Evaporation (Distillation) See § B.5.6.3	Both	High	Moderate	Very high capital; High O&M	Best suited to lower flows, and may not be suited to treatment at the Site if water is extracted from the Wells Fm. because of possibly high discharge rates. The concentrations of all ions in the Site GW would be reduced.	All areas where GW is collected and requires treatment for disposal.	Thermal evaporation/distillation is not retained due to very high capital and O&M costs compared to other equally effective technologies (e.g. membranes).	Reject
Biological Processes								
Ex-Situ Biological See § B.5.6.4	Both	High	High	Low to moderate capital,; Moderate O&M	High concentrations of sulfate can affect the efficiency of selenium treatment; however, this was shown not to be an issue during the P4 pilot testing of the technology. Winter temperatures can reduce treatment efficiency.	All areas where GW is collected and requires treatment for disposal.	Biological treatment is retained because the technology was demonstrated at the Ballard Site.	Retain
In-Situ Treatment								
Chemical Processes								
Chemical Injection (Reduction) See § B.5.7.1	Alluvial	Moderate to High	High	Moderate capital; Low O&M	The alluvial unit is shallow and unconsolidated and is therefore easy to treat with a large number of borings. The Wells Fm requires deep bedrock drill holes, but has higher permeability and greater dispersion of injected chemicals. The chemical composition of Site GW (e.g., species present and competing ions) also will affect the effectiveness of the chemical treatment.	All areas of GW contamination, but may have limited effectiveness and implementability in the Wells Fm.	Likely to be effective for remediating Site COCs in GW. Implementation in the alluvial unit is straightforward, whereas, implementation in the Wells Fm would be complex.	Retain
	Wells Fm	Low	Low	High capital; Low O&M				Reject
Reactive Barriers See § B.5.7.1	Alluvial	Low to High	High	Moderate capital; Low O&M	The alluvial unit is shallow and unconsolidated, and it is therefore straightforward to constructed PRBs.	All areas of GW contamination, but may have limited effectiveness and implementability in the Wells Fm.	PRBs have been used with success to treat GW contaminated with inorganic COCs. Effectiveness and implementability in the alluvial unit is likely to be high.	Retain
	Wells Fm	Low	Low	High capital; Moderate O&M	The Wells Fm is a deep bedrock unit, making construction of a reactive barrier difficult, relying on closely spaced wells and the dispersion of reactive material within the aquifer.		PRB implementation in the Wells Fm would be via deep borings, and therefore, implementation would be difficult and likely would result in low effectiveness.	Reject
Biological Processes								
In-Situ Biological See § B.5.7.2	Alluvial	Moderate to High	High	Moderate capital; Low O&M	The alluvial unit is shallow and unconsolidated and is therefore easy to treat with a large number of borings. The Wells Fm requires deep bedrock drill holes, but has higher permeability and greater dispersion of injected chemicals. The chemical composition of the GW (e.g., species present and competing ions) also will affect the effectiveness of the biological treatment.	All areas of GW contamination, but may have limited effectiveness and implementability in the Wells Fm.	In-situ biological reduction would be effective for remediating Site COCs in GW. Implementation in the alluvial unit is straightforward.	Retain
	Wells Fm	Low	Moderate	High capital; Low O&M			Implementation in the Wells Fm is very complex and would be difficult to demonstrate effectiveness.	Reject

Notes:

The treatment technologies and/or process options in the blue shaded cells have been eliminated from further evaluation in the development of alternatives.

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APPENDICES

Appendix A
Development of Risk-Based Cleanup Levels for Soil and Sediment, Ballard Mine

FINAL

MAY 2016

Prepared by
MWH

Prepared for:
P4 Production, LLC

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ACRONYMS AND ABBREVIATIONS

BRA	baseline risk assessment
COC	contaminant of concern
COEC	contaminant of ecological concern
EPC	exposure point concentration
ERBCL	ecological risk based cleanup level
FS	feasibility study
kg	kilogram
HI	hazard index
HQ	hazard quotient
LCOC	livestock contaminant of concern
MCL	maximum contaminant level
mg	milligram
MWH	MWH Americas, Inc.
NOAEL	no observed adverse effects
P4	P4 Production, LLC
PCL	preliminary cleanup level
PRG	preliminary remediation goal
RBCL	risk based cleanup level

RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RME	reasonable maximum exposure
ROC	radionuclide of concern
TRV	toxicity reference value
THQ	target hazard quotient
TR	target risk
UCL	upper confidence limit
USEPA	United States Environmental Protection Agency

1.0 INTRODUCTION

This appendix to the *Ballard Mine Feasibility Study Report Memorandum 1 – Site Background and Screening Technologies* (Ballard FS Memo #1) was prepared by MWH Americas, Inc. (MWH) on behalf of P4 Production, LLC (P4), as part of the comprehensive mine-specific Remedial Investigation /Feasibility Study (RI/FS) that is being conducted at P4's three historic phosphate mines, namely Ballard, Henry and Enoch Valley Mines (collectively known as the "Sites"), located in southeast Idaho. This appendix presents the methods used to calculate risk-based cleanup levels (RBCLs) protective of human health and ecological exposures to chemicals identified as risk drivers for human, ecological, and livestock receptors at the Ballard Site.

The resultant human health RBCLs are presented in Tables A-1 through A-11, ecological RBCLs are presented in Tables A-12 through A-26, and livestock RBCLs are presented in Tables A-27 and A-28. In addition to RBCLs, this appendix includes index plots that graphically present the background datasets, background summary statistics, and Ballard Site data for key constituents (refer to Attachment 1). Index plots were prepared at the request of the A/T and are intended to put the RBCLs into numeric context.

1.1 PURPOSE AND SCOPE

Preliminary cleanup levels (PCLs) for risk-driving contaminants of concern (COCs), radionuclides of concern (ROCs), contaminants of ecological concern (COECs) and livestock contaminants of concern (LCOC) for solid media (i.e., upland soil, riparian soil, and sediment) identified in the Remedial Investigation (RI) for the Ballard Mine were developed in consideration of Site-specific RBCLs that are protective of human, ecological, and livestock receptors and Site-specific background values [MWH, 2013; MWH 2014]. The purpose of this appendix is to describe the assumptions and methods used to calculate medium-specific human health, ecological, and livestock RBCLs, present the receptor-specific RBCLs for each COC/ROC/COEC/LCOC in soils and sediments, and to identify the most protective (i.e., the lowest) RBCLs for all receptors for each COC/ROC/COEC/LCOC. Soil and sediment RBCLs were calculated for all receptors evaluated in the Baseline Risk Assessment (*Ballard BRA*) included in the *Ballard Mine RI Report* (MWH, 2014) such that the protectiveness of the selected PCL for each COC/ROC/COEC/LCOC can be evaluated. Groundwater and surface water do not have Site-specific cleanup levels because the remediation goals default to maximum contaminant levels (MCLs) and other applicable standards that are widely accepted for remediation of these media. Vegetation is a secondary medium that is addressed through remediation of the primary medium (soil and sediment). However, published performance targets may be used to evaluate the effectiveness of this RA as described in Ballard FS Memo #1.

2.0 HUMAN HEALTH RBCLS

This section describes the methods and assumptions used to calculate RBCLs for human receptors. Human health RBCLs for soil and sediment were calculated for all COCs/ROCs and potentially exposed human receptors, regardless of the chemical-specific risk and hazard estimates calculated in the BRA. The RBCLs for carcinogenic effects are based on a target cancer risk of 1×10^{-4}, and the RBCLs for non-carcinogenic effects are based on a target hazard quotient (HQ) of 1. For evaluation of cancer risk levels other than 1×10^{-4} (i.e., 1×10^{-5} or 1×10^{-6}), the cancer-based cleanup level should be divided by the appropriate factor of 10 (e.g., 100 for 1×10^{-6}).

2.1 GENERAL RBCL METHODS FOR HUMAN HEALTH

The Site-specific soil and sediment RBCLs for human receptors were calculated using the Tier II Reasonable Maximum Exposure (RME) exposure pathways and assumptions that were evaluated in the *Ballard BRA*. In order to calculate a cumulative RBCL that includes all direct and indirect exposure pathways, a sum of fractions approach was used. The sum of fractions approach is analogous to summing pathway specific cancer risk or non-carcinogenic HQ values to obtain a cumulative risk or hazard index (HI), except that for a cumulative RBCL, the inverse of the pathway-specific RBCLs are summed:

(1)

$$\mathrm{RBCL}_{\mathrm{cumulative}} = \frac{1}{\frac{1}{\mathrm{RBCL}_{\mathrm{direct\ exposure}}} + \frac{1}{\mathrm{RBCL}_{\mathrm{indirect\ exposure}}}}$$

Where

$\mathrm{RBCL}_{\mathrm{cumulative}}$ = cumulative medium-specific RBCL
$\mathrm{RBCL}_{\mathrm{direct\ exposure}}$ = medium-specific RBCL for direct exposure pathways
$\mathrm{RBCL}_{\mathrm{indirect\ exposure}}$ = medium-specific RBCL for indirect exposure pathways

Upland soil RBCLs were calculated for all five human receptors evaluated in the BRA; riparian soil and sediment RBCLs were calculated for the current/future Native American only, as the other receptors are not significantly exposed to these media. RBCLs for ROCs in upland soil were calculated using the USEPA's online Preliminary Remediation Goals (PRGs) Calculator (USEPA, 2014), as described in the *BRA Addendum* (MWH, 2015), and summarized in Section 2.5 below.

2.2 UPLAND SOIL RBCLS

The upland soil exposure pathways that were evaluated in the *Ballard BRA* include direct contact pathways (i.e., incidental ingestion of soil, inhalation of dust, and dermal contact with soil) and indirect pathways (i.e., ingestion of plants grown in upland soil and elk and cattle that forage on plants grown in upland soil).

2.2.1 Direct Exposure

The direct exposure RBCLs for upland soil were calculated using the exposure point concentration (EPC) and risk or hazard estimates for this pathway from the *Ballard BRA* as follows:

RBCL for carcinogenic chemicals:

(2) $$\mathrm{RBCL} = \frac{\mathrm{EPC}}{\mathrm{risk}} \times \mathrm{TR}$$

and RBCL for noncarcinogenic chemicals:

(3) $$\mathrm{RBCL} = \frac{\mathrm{EPC}}{\mathrm{hazard}} \times \mathrm{THQ}$$

Where

RBCL = risk based screening level (milligrams per kilogram [mg/kg])
EPC = exposure point concentration (mg/kg)
Risk = chemical specific risk (unitless)
Hazard = chemical specific hazard (unitless)
TR = target risk (unitless; 1 x 10^{-4})
THQ = target hazard quotient (unitless; 1)

Upland soil RBCLs were calculated from the upland soil EPCs and risk and hazard estimates presented in Table A-1. Upland soil direct exposure assumptions, and therefore upland soil RBCLs, for the current/future Native American and hypothetical future resident are equivalent and are included together in Table A-1.

2.2.2 Indirect Exposure Plant Ingestion

In the *Ballard BRA*, the Native American receptor was assumed to consume culturally significant plant tissue, while the hypothetical future resident was assumed to consume home-grown fruits and vegetables. No other human receptor included a plant ingestion pathway. Culturally significant upland plants were assumed in the *Ballard BRA* to uptake COCs from upland soil only, while fruits and vegetables uptake COCs from upland soil and groundwater used for irrigation. For the upland soil RBCL calculations, the contribution from groundwater to the modeled concentrations of COCs in fruits and vegetables was removed. The RBCLs for the Native American and hypothetical future resident are equivalent when the plant tissue concentrations are modeled from upland soil. In the *Ballard BRA*, however, when measured concentrations of COCs in plant tissue data were available, measured concentrations were used in place of modeled concentrations. Although the plant consumption RBCLs are equivalent for the Native American and hypothetical future resident when modeled plant concentrations are used, RBCLs based on measured plant data are not equivalent for these receptors. This is because the RBCL for the Native American is based on culturally significant plant tissue data, while the RBCL for the hypothetical future resident is based on the entire (i.e., culturally significant and non-culturally significant) plant dataset. For consistency with the *Ballard BRA*, RBCLs for plant consumption were based on measured plant tissue data, where available. This was achieved by assuming a linear relationship between measured soil concentrations and measured plant concentrations. The ratio of the 95% upper confidence limit (UCL) on the mean concentration in plant tissue to the 95% UCL on the mean concentration in upland soil was used in place of the wet soil-to-plant uptake and mass loading factor values in the modeled plant concentration portion of the dose equation. The RBCLs for carcinogenic and non-carcinogenic chemicals were then calculated according to equations (2) and (3) above.

Table A-2 presents the EPC, measured plant concentration, modeled plant concentration, risk and hazard estimates from the *Ballard BRA*, and RBCLs for culturally significant plant ingestion. Tables A-2a and A-2b present the cancer risk and noncancer hazard calculations for culturally significant plants presented in the *Ballard BRA,* in addition to the upland soil RBCL associated with a cancer risk of 1×10^{-4} and HQ of 1, respectively.

Table A-3 presents the EPC, measured plant concentration, modeled plant concentration, risk and hazard estimates from the *Ballard BRA*, and RBCLs for the fruit and vegetable pathway. Tables A-3a and A-3b present the cancer risk and noncancer hazard calculations for fruit and vegetables presented in the *Ballard BRA,* in addition to the upland soil RBCL associated with a cancer risk of $1x10^{-4}$ and HQ of 1, respectively.

2.2.3 Indirect Exposure Elk and Cattle Tissue Ingestion

Consumption of tissue from elk that have foraged on vegetation growing in upland soil is a complete exposure pathway for the current/future Native American and current/future recreational hunter. This pathway was evaluated for the Native American in the Tier I risk evaluation, where it was determined that elk tissue was not a medium of concern to be carried forward into the Tier II risk evaluation. Therefore, elk consumption was not evaluated for the Native American or current/future recreational hunter in the Tier II risk evaluation. However, RBCLs were calculated for all receptors and exposure pathways evaluated in the BRA, regardless of the magnitude of the associated risk estimates. Elk tissue concentrations for the Native American in the Tier I risk evaluation in the *Ballard BRA* were modeled from upland soil and surface water; for the upland soil RBCLs, the contribution from surface water was removed. The RBCLs for upland soil for the elk consumption pathway, along with EPCs, modeled elk tissue concentrations, and risk and hazard estimates from the *Ballard BRA*, are presented in Table A-4. Cancer- and noncancer-based RBCLs, calculated according to equations (2) and (3) above, are shown in Tables A-4a and A-4b, respectively.

Consumption of tissue from cattle that have foraged on vegetation growing in upland soil is a complete exposure pathway for the current/future seasonal rancher. Cattle tissue concentrations were modeled from upland soil and surface water, and from upland soil and groundwater, with the higher risk of the two water sources included in the cumulative risk and hazard estimate in the *Ballard BRA*. For the upland soil RBCLs, the contribution from water was removed from the modeled tissue concentration. The RBCLs for upland soil for the cattle consumption pathway, along with EPCs, modeled cattle tissue concentrations, and risk and hazard estimates from the *Ballard BRA*, are presented in Table A-5. Cancer- and non-cancer-based RBCLs, calculated according to equations (2) and (3) above, are shown in Tables A-5a and A-5b, respectively.

2.3 RIPARIAN SOIL RBCLS

The riparian soil exposure pathways that were evaluated in the *Ballard BRA* include direct contact pathways (i.e., incidental ingestion of riparian soil, inhalation of dust, and dermal contact with riparian soil) and indirect pathways (i.e., ingestion of plants grown in riparian soil). As stated in Section 2.1, these pathways were evaluated for the Native American only.

2.3.1 Direct Exposure

The direct exposure RBCLs for riparian soil were calculated using the EPC and risk or hazard estimates for this pathway from the *Ballard BRA* using equations (2) and (3) above. Riparian soil RBCLs for the direct contact pathway were calculated from the riparian soil EPCs and risk and hazard estimates presented in Table A-6.

2.3.2 Indirect Exposure Plant Consumption

Consistent with the *Ballard BRA*, riparian plant consumption RBCLs were calculated using measured concentrations of COCs in culturally significant riparian plant tissue, where available. As with upland soil RBCLs, this was achieved by assuming a linear relationship between measured riparian soil concentrations and measured culturally significant riparian plant concentrations. The ratio of the 95% UCL on the mean concentration in riparian plant tissue to the 95% UCL on the mean concentration in riparian soil was used in place of the wet soil-to-plant uptake and mass loading factor values in the modeled plant concentration portion of the dose equation. The RBCLs for carcinogenic and non-carcinogenic chemicals were then calculated according to equations (2) and (3) above.

The EPC, measured plant concentration, modeled plant concentration, risk and hazard estimates from the *Ballard BRA*, and RBCLs for culturally significant plants harvested from riparian soil are provided in Table A-7. Tables A-7a and A-7b present the cancer risk and noncancer hazard calculations for culturally significant plants presented in the *Ballard BRA,* in addition to the riparian soil RBCL associated with a cancer risk of $1x10^{-4}$ and HQ of 1, respectively.

2.4 SEDIMENT RBCLS

Sediment exposure was evaluated in the *Ballard BRA* based on consumption of culturally significant aquatic vegetation by a Native American. No measured tissue concentrations were available for aquatic plants and therefore uptake from sediment to plants was modeled from literature uptake factors and equations in both the *Ballard BRA* risk and hazard calculations and the RBCL calculations. The literature-based sediment-to-plant uptake models include nonlinear regressions for some metals such that equations (2) and (3) cannot be used to derive RBCLs. The sediment RBCLs for these COCs were calculated numerically by selecting a goal value of 1 for the HQ in the Solver tool in Microsoft Excel. Because only one exposure pathway for sediment was evaluated in the *Ballard BRA*, the indirect exposure RBCL for aquatic plant consumption is also the cumulative sediment RBCL.

The EPC, modeled aquatic plant concentration, risk and hazard estimates from the *Ballard BRA*, and RBCLs for aquatic plants are provided in Table A-8. Tables A-8a and A-8b present the cancer risk and noncancer hazard calculations for aquatic plants presented in the *Ballard BRA,* in addition to the sediment RBCL associated with a cancer risk of $1x10^{-4}$ and HQ of 1, respectively.

2.5 RADIOLOGICAL RBCLS

Radiological risks associated with exposure to radium-226 and radon-222 in upland soil presented in the *Ballard BRA* and in the *Ballard BRA Addendum* were calculated using modeled concentrations of these ROCs and preliminary remediation goals (PRGs) derived from the USEPA's PRGs Calculator (USEPA, 2014). Radiological PRGs and cancer risk estimates presented in the *Ballard BRA* were for hypothetical future residential exposure only, and were based on default exposure assumptions for this receptor. Radiological PRGs and cancer risk estimates presented in the *Ballard BRA Addendum* were calculated for the current/future Native American, seasonal rancher, recreational hunter, and camper/hiker. Because the upland soil direct exposure and plant ingestion pathways are equivalent for the hypothetical future resident and the current/future Native American, default PRGs for the hypothetical future resident exposed to these media in the *Ballard BRA* were replaced with Site-specific PRGs for the current/future Native American that were presented in the *Ballard BRA Addendum*. Radiological RBCLs for all human health receptors exposed to upland soil are presented in Table A-9.

2.6 CUMULATIVE RBCLS

Cumulative RBCLs for upland soil were calculated for the current/future Native American and hypothetical future resident according to equation (1) above, where:

$$\mathrm{RBCL_{indirect}} = \frac{1}{\frac{1}{\mathrm{RBCL_{plant\ tissue}}} + \frac{1}{\mathrm{RBCL_{elk\ or\ cattle\ tissue}}}}$$

Upland soil RBCLs for the current/future seasonal rancher, recreational hunter, and camper/hiker are based on direct soil exposures only, and the cumulative RBCL is equal to the medium-specific RBCL. Cumulative upland soil RBCLs for all receptors are presented in Table A-10.

Cumulative RBCLs for riparian soil include only one indirect pathway, and were calculated according to equation (1). Sediment was evaluated through indirect exposure only, and the cumulative RBCL is equal to the medium-specific aquatic plant RBCL. Riparian soil and sediment RBCLs are presented in Table A-11.

3.0 ECOLOGICAL RBCLS

This section describes the methods and assumptions that were used to calculate Site-specific ecological RBCLs (ERBCLs) for soil and sediment. Site-specific ERBCLs for constituents identified as COEC were calculated for all ecological receptors evaluated in the *Ballard BRA*, regardless of the receptor-specific hazard estimate for each COEC.

3.1 GENERAL RBCL METHODS FOR ECOLOGICAL RECEPTORS

Ecological hazard estimates presented in the *Ballard BRA* accounted for a cumulative exposure from multiple media (e.g., upland soil and surface water for a deer mouse; riparian soil, surface water, and sediment for a mink). Medium-specific ERBCLs were calculated by assuming exposure to one medium at a time, as described in the following subsections. The ERBCLs were calculated to achieve a medium-specific ecological HQ of 1, using no observed adverse effects level (NOAEL)-based toxicity reference values (TRVs). The ingestion dose equations for some ecological receptors include non-linear equations for uptake from soil or sediment to prey items, and therefore ERBCLs were determined numerically using the Solver tool in Microsoft Excel.

3.2 UPLAND SOIL ERBCLS

Ecological receptors evaluated for exposure to upland soil in the *Ballard BRA* include the long-tailed vole, deer mouse, American goldfinch, American Robin, coyote, and northern harrier. In order to calculate upland soil ERBCLs, the contribution of water to the total COEC dose was removed for those chemicals with a surface water EPC in the *Ballard BRA*. Consistent with the *Ballard BRA*, measured concentrations of COECs in plant tissue, where available, were used in place of modeled concentrations. This was achieved by assuming a linear relationship between measured soil concentrations and the measured plant concentrations. The ratio of the 95% UCL on the mean concentration in plant tissue to the 95% UCL on the mean concentration in upland soil was used in place of the soil-to-plant bioaccumulation factor or regression in the modeled plant concentration portion of the dose equation. As mentioned above, the soil-to-invertebrate and soil to vertebrate uptake models for some COECs are based on non-liner bioaccumulation regressions, and therefore the ERBCL was solved numerically by setting the ecological HQ to a goal value of 1 in the Solver tool in Microsoft Excel.

Upland soil ERBCLs for the long-tailed vole, deer mouse, American goldfinch, American Robin, coyote, and northern harrier are presented in Tables A-12 through A-18.

3.3 RIPARIAN SOIL ERBCLS

Ecological receptors evaluated for exposure to riparian soil in the *Ballard BRA* include the raccoon, mink, and great blue heron. The hazard estimates presented in the *Ballard BRA* for the raccoon, mink, and great blue heron include exposure to COECs in riparian soil, sediment, and surface water. In order to calculate riparian soil ERBCLs, it was assumed that these receptors are exposed to riparian soil only. For the raccoon, water ingestion was removed from the dose equation, and the diet was modified to include 10% terrestrial vertebrates and 26% terrestrial invertebrates. For the mink, water ingestion was removed from the dose equation, and the diet was modified so that terrestrial vertebrates comprised 100% of prey items. For the great blue heron, water and sediment ingestion were removed from the dose equation, and the diet was modified to include 50% terrestrial invertebrates and 50% terrestrial vertebrates. The soil to invertebrate and soil to vertebrate uptake models for some COECs are based on bioaccumulation regressions and, therefore, the ERBCL was solved numerically by setting the ecological HQ to a goal value of 1 in the Solver tool in Microsoft Excel. No riparian soil ERBCLs were calculated for antimony because the EPC for this metal was less than the concentration in background riparian soils.

Riparian soil ERBCLs for the raccoon, mink, and great blue heron are presented in Tables A-19 through A-21.

3.4 SEDIMENT ERBCLS

Ecological receptors evaluated for exposure to sediment in the *Ballard BRA* include the raccoon, mallard, mink, and great blue heron. The hazard estimates presented in the *Ballard BRA* for the mallard include exposure to COECs in surface water and sediment; the hazard estimates for the raccoon, mink, and great blue heron include exposure to COECs in surface water, riparian soil, and sediment. In order to calculate sediment ERBCLs, it was assumed that these receptors are exposed to sediment only. For the mallard, surface water ingestion was removed from the dose equation. For the raccoon, surface water and riparian soil were removed from the dose equation, and the diet was modified to include 26% from aquatic invertebrates and 10% from fish. For the mink, surface water and riparian soil were removed from the dose equation, and the diet was modified to include

16% from aquatic invertebrates, and 84% from fish. For the great blue heron, surface water was removed from the dose equation, and the diet was modified such that fish comprised 100% of prey items. No sediment ERBCLs were calculated for chromium and nickel, as these chemicals were identified as COECs for riparian soil, only. Sediment ERBCLs were solved numerically by setting the ecological HQ to a goal value of 1 in the Solver tool in Microsoft Excel

Sediment ERBCLs for the raccoon, mink, great blue heron, and mallard are presented in Tables A-22 through A-25.

3.5 ERBCL SUMMARY

Upland soil, riparian soil, and sediment ERBCLs for all COECs and ecological receptors are summarized in Table A-26.

4.0 LIVESTOCK RBCLS

A site-specific upland soil livestock RBCL for selenium was calculated for beef cattle, as described below.

4.1 GENERAL METHODS AND RBCLS FOR BEEF CATTLE

The only LCOC identified for beef cattle was selenium. The methods for calculating the selenium RBCL for livestock are the same as those for calculating upland soil ERBCLs. The calculation of the livestock RBCL for selenium is shown in Table A-27, and the livestock RBCL is presented in Table A-28.

5.0 REFERENCES

MWH Americas, Inc. (MWH), 2013. *Ballard, Henry, and Enoch Valley Mines Remedial Investigation and Feasibility Study Background Levels Development Technical Memorandum*. March.

MWH, 2014. *Ballard Mine Remedial Investigation and Feasibility Study Remedial Investigation Report.* Final. November.

MWH, 2015. *Ballard Mine Remedial Investigation Report Baseline Risk Assessment Addendum*. Final Revision 1. February.

United States Environmental Protection Agency [USEPA], 2014. *Preliminary Remediation Goals for Radionuclides*. http://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search Accessed November 11.

TABLES

Table A-1
Summary of Risk-Based Cleanup Levels for Upland Soil - Direct Contact

COC	Upland Soil EPC[a] (mg/kg)	Risk and Ha ard Estimates (unitless) for:								Risk- and Ha ard-Based Cleanup Levels[b] (mg/kg) for:							
		Current/Future Native American and Hypothetical Future Resident		Current/Future Seasonal Rancher		Current/Future Recreational Hunter		Current/Future Recreational Camper/Hiker		Current/Future Native American and Hypothetical Future Resident		Current/Future Seasonal Rancher		Current/Future Recreational Hunter		Current/Future Camper Hiker	
		ILCR	HQ	ILCR	HQ	ILCR	HQ	ILCR	HQ	Risk-Based	Ha ard-Based	Risk-Based	Ha ard-Based	Risk-Based	Ha ard-Based	Risk-Based	Ha ard-Based
Antimony	4.89	NA	0.066	NA	0.025	NA	0.0014	NA	0.0017	NA	74.4	NA	194	NA	3,425	NA	2,912
Arsenic	21.8	**4.1E-05**	0.21	**1.2E-05**	0.076	7.0E-07	0.0046	1.1E-06	0.0055	53.3	103	186	286	3,104	4,781	2,074	3,998
Cadmium	37.6	2.8E-10	0.16	1.3E-09	0.054	1.4E-10	0.0035	8.6E-11	0.0042	NA[c]	230	NA[c]	698	NA[c]	10,801	NA[c]	8,861
Molybdenum	20.0	NA	0.013	NA	0.003	NA	0.00026	NA	0.00034	NA	1,562	NA	7,054	NA	78,011	NA	59,092
Selenium	53.5	NA	0.044	NA	0.014	NA	0.00092	NA	0.0011	NA	1,221	NA	3,947	NA	58,280	NA	47,017
Thallium	1.20	NA	0.38	NA	0.085	NA	0.0077	NA	0.010	NA	3.12	NA	14.1	NA	156	NA	118
Uranium	38.3	NA	0.204	NA	0.0453	NA	0.00410	NA	0.0054	NA	187	NA	845	NA	9,348	NA	7,087

Notes:

[a] The exposure point concentration (EPC) is the lower of the maximum detected concentration or 95%, 97.5% or 99% UCL on the mean concentration measured in upland soil samples collected from Ballard Mine sampling locations.

[b] Risk- and hazard-based cleanup levels are calculated for a chemical-specific ILCR and HQ of $1x10^{-4}$ and 1, respectively. Cancer-based cleanup levels are calculated as the EPC divided by the ILCR multiplied by 10^{-4}; noncancer hazard-based cleanup levels are calculated as the EPC divided by the HQ.

[c] Risk-based cleanup level exceeds $1x10^{6}$ milligrams per kilogram; health effects negligible.

Bold indicates exceedance of the USEPA's risk management range and/or IDEQ's point of departure.

% UCL - percent upper confidence limit
COC - constituent of concern
EPC - exposure point concentration
HQ - hazard quotient
IDEQ - Idaho Department of Environmental Quality
ILCR - incremental lifetime cancer risk
mg/kg - milligrams per kilogram
NA - not applicable
USEPA - U. S. Environmental Protection Agency

Table A-2
Summary of Risk-Based Cleanup Levels - Culturally Significant Plants - Upland Soil

COC	Upland Soil EPC[a] (mg/kg)	Modeled Culturally Significant Plant Concentration[b] (mg/kg)	Measured Culturally Significant Plant Concentration[c] (mg/kg)	Risk and Ha ard Estimates for the Current/Future Native American[d] (unitless)		Risk- and Ha ard-Based Cleanup Levels for the Current/Future Native American[e] (mg/kg)	
				ILCR	**HQ**	**Risk-Based**	**Ha ard-Based**
Antimony	4.89	1.52	na	NA	**20**	NA	0.248
Arsenic	21.8	5.89	0.486	**1.6E-03**	**8.4**	1.34	2.59
Cadmium	37.6	14.5	0.773	NA	**4.0**	NA	9.35
Molybdenum	20.0	6.45	0.608	NA	0.63	NA	31.6
Selenium	53.5	14.3	41.8	NA	**44**	NA	1.23
Thallium	1.20	0.313	0.00493	NA	**2.6**	NA	0.468
Uranium	38.3	10.0	0.100 [f]	NA	**87**	NA	44.2

Notes:

[a] The lower of the maximum detected concentration and ProUCL recommended 95%, 97.5% or 99% UCL on the mean concentration measured in upland soil samples collected from Ballard Mine sampling locations.

[b] The modeled culturally significant plants EPC shown here was calculated from the upland soil EPC using soil-to-plant uptake factors.

[c] The lower of the maximum detected concentration and ProUCL recommended 95%, 97.5% or 99% UCL on the mean concentration measured in culturally significant plants samples in wet weight. The dry weight culturally significant plants data were converted to wet weight using an average moisture content of 66 percent.

[d] The ILCR and HQ estimates were based on measured plant data, where available, except for uranium, which was not detected.

[e] Risk- and hazard-based cleanup levels are based on RME exposure assumptions and measured plant data, where available, and calculated for a chemical-specific ILCR and HQ of $1x10^{-4}$ and 1 as shown in Table A-2a and Table A-2b, respectively.

[f] Uranium was not detected in upland culturally significant plant tissue. The upland culturally significant plant hazard estimate of 87 presented in the Ballard BRA was based on a modeled plant tiessue concentration of 10.0 mg uranium / kg plant. The maximum detection limit for uranium in plant tissue was 0.100 mg/kg; this maximum detection limit was used to calculate the risk-based cleanup level for uranium.

Bold indicates exceedance of the USEPA's risk management range and/or IDEQ's point of departure.

% UCL - percent upper confidence limit
COC - chemical of concern
EPC - exposure point concentration
HQ - hazard quotient
IDEQ - Idaho Department of Environmental Quality
ILCR - incremental lifetime cancer risk
mg/kg - milligrams per kilogram
NA - not applicable
na - not available
RME - reasonable maximum exposure
USEPA - U. S. Environmental Protection Agency

Table A-2a
Cancer Risk-Based Cleanup Level Calculation for Upland Soil - Culturally Significant Plants

COC	Upland Soil Concentration[a] (mg/kg)	Upland Soil Cleanup Level[b] (mg/kg)	Modeled Culturally Significant Plant Concentration from Soil[c] (mg/kg)	Measured Culturally Significant Plant Concentration[c] (mg/kg)	Modeled Plant Ingestion Dose (mg/kg-d)	Measured Plant Ingestion Dose (mg/kg-d)	Cancer Slope Factor $(mg/kg\text{-}d)^{-1}$ [d] Oral	Pathway-Specific Cancer Risk: Modeled Plant Ingestion	Pathway-Specific Cancer Risk: Measured Plant Ingestion	Chemical-Specific Risk [e]
Arsenic	21.8	--	5.89	0.486	1.3E-02	1.1E-03	1.5E+00	2.0E-02	1.6E-03	**1.6E-03**
	--	1.34	0.0299	NA	6.7E-05	NA	1.5E+00	1.0E-04	NA	**1.0E-04**

Notes:

[a] The lower of the maximum detected concentration and ProUCL recommended 95%, 97.5% or 99% UCL on the mean concentration measured in upland soil samples collected from Ballard Mine sampling locations.

[b] The cancer risk-based upland soil cleanup level associated with RME exposures to upland culturally significant plants was calculated based on measured plant data by replacing the modeled plant concentration based on published uptake factors with a modeled concentration based on measured data, as described below, and solving for the soil concentration that resulted in a chemical-specific cancer risk of 1×10^{-4}.

[c] The literature-based modeled plant concentration was calculated as the wet soil to plant uptake plus mass loading factor multiplied by the soil concentration. For calculation of site-specific cleanup levels, the modeled plant concentration was calculated as the ratio of the measured plant concentration to the measured soil concentration, multiplied by the soil cleanup level that resulted in a chemical-specific cancer risk of 1×10^{-4}.

[d] Doses and risks shown only for carcinogenic chemicals with available toxicity values.

[e] Measured upland culturally significant plant data were used when available.

% UCL	percent upper confidence limit	mg/kg-d	milligrams per kilogram per day
COC	chemical of concern	NA	not applicable
ILCR	incremental lifetime cancer risk	RME	reasonable maximum exposure
mg/kg	milligrams per kilogram		

Table A-2b
Noncancer Risk-Based Cleanup Level Calculations for Upland Soil - Culturally Significant Plants

COC	Upland Soil Concentration[a] (mg/kg)	Upland Soil Cleanup Level[b] (mg/kg)	Modeled Culturally Significant Plant Concentration from Soil[c] (mg/kg)	Measured Culturally Significant Plant Concentration[c] (mg/kg)	Modeled Plant Ingestion Dose (mg/kg-d)	Measured Plant Ingestion Dose (mg/kg-d)	Reference Dose (mg/kg-d) [d]	Pathway-Specific Ha ard		Chemical-Specific HQ[e]
							Oral	Modeled Plant Ingestion	Measured Plant Ingestion	
Antimony	4.89	--	1.52	na	7.9E-03	na	4.0E-04	20	na	**20**
	--	0.248	0.0769	na	4.0E-04	NA	4.0E-04	1.0	na	1.0
Arsenic	21.8	--	5.89	0.486	3.1E-02	2.5E-03	3.0E-04	102	8.4	**8.4**
	--	2.59	0.0576	NA	3.0E-04	NA	3.0E-04	1.0	NA	1.0
Cadmium	37.6	--	14.5	0.773	7.5E-02	4.0E-03	1.0E-03	75	4.0	**4.0**
	--	9.35	0.192	NA	1.0E-03	NA	1.0E-03	1.0	NA	1.0
Molybdenum	20.0	--	6.45	0.608	3.4E-02	3.2E-03	5.0E-03	6.7	0.63	0.63
	--	31.6	0.961	NA	5.0E-03	NA	5.0E-03	1.0	NA	1.0
Selenium	53.5	--	14.3	41.8	7.4E-02	2.2E-01	5.0E-03	15	44	**44**
	--	1.23	0.961	NA	5.0E-03	NA	5.0E-03	1.0	NA	1.0
Thallium	1.20	--	0.313	0.00493	1.6E-03	2.6E-05	1.0E-05	163	2.6	**2.6**
	--	0.468	0.00192	NA	1.0E-05	NA	1.0E-05	1.0	NA	1.0
Uranium	38.3	--	10.0	0.100	5.2E-02	5.2E-04	6.0E-04	87	0.87	**87** [f]
	--	44.2	0.115	NA	6.0E-04	na	6.0E-04	1.0	na	1.0

Notes:

[a] The lower of the maximum detected concentration and ProUCL recommended 95%, 97.5% or 99% UCL on the mean concentration measured in upland soil samples collected from Ballard Mine sampling locations.

[b] The noncancer hazard-based upland soil cleanup level associated with RME exposures to upland culturally significant plants was calculated based on measured plant data where available by replacing the modeled plant concentration based on published uptake factors with a modeled concentration based on measured data where available, as described below. The cleanup level is the soil concentration that results in a chemical-specific hazard of 1.

[c] The literature-based modeled plant concentration was calculated as the wet soil to plant uptake plus mass loading factor multiplied by the soil concentration. For calculation of site-specific cleanup levels, the modeled plant concentration was calculated as the ratio of the measured plant concentration to the measured soil concentration, multiplied by the soil cleanup level that resulted in a chemical-specific noncancer hazard of 1.

[d] Doses and noncancer hazards shown only for noncarcinogenic chemicals with available toxicity values.

[e] Measured upland culturally significant plant data were used when available.

[f] The uranium hazard estimate of 87 presented in the Ballard BRA was based on the modeled tissue concentration of 10.0 mg/kg because uranium was not detected in culturally significant upland plant tissue. The risk-based cleanup level for uranium is based on the maximum detected tissue concentration of 0.100 mg/kg.

% UCL	percent upper confidence limit	mg/kd-d	milligrams per kilogram per day
COC	constituent of concern	NA	not applicable
HI	hazard index	na	not available
HQ	hazard quotient	RME	reasonable maximum exposure
mg/kg	milligrams per kilogram		

Table A-3
Summary Risk-Based Cleanup Levels for Upland Soil - Fruits and Vegetables

COC	Upland Soil EPC[a] (mg/kg)	Groundwater EPC[a] (mg/L)	Modeled Total Fruits and Vegetables Concentration[b] (mg/kg)	Measured Non-Culturally Significant Plant Concentration[c] (mg/kg)	Risk and Ha ard Estimates for the Hypothetical Future Resident[d] (unitless)		Risk- and Ha ard-Based Cleanup Levels for the Hypothetical Future Resident[e] (mg/kg)	
					ILCR	HQ	Risk-Based	Ha ard-Based
Antimony	4.89	NA	1.52	na	NA	**20**	NA	0.248
Arsenic	21.8	0.0119	0.664	0.506	**2.2E-03**	**12**	1.29	2.49
Cadmium	37.6	0.00195	0.492	0.458	NA	**2.6**	NA	15.8
Molybdenum	20.0	NA	7.32	7.32	NA	**7.6**	NA	2.62
Selenium	53.5	0.480	20.5	14.2	NA	**21**	NA	3.62
Thallium	1.20	0.000286	0.0554	0.0517	NA	**29**	NA	0.0447
Uranium	38.3	NA	0.0435	0.0435	NA	0.38	NA	101

Notes:

[a] The EPCs used to model fruits and vegetables concentration is the lower of the maximum detected concentration and the ProUCL recommended 95%, 97.5% or 99% UCL on the mean concentration measured in upland soil and groundwater samples collected from Ballard Mine sampling locations.

[b] The fruits and vegetables EPC was modeled from the upland soil and groundwater EPCs using plant uptake factors.

[c] The lower of the maximum detected concentration and ProUCL recommended 95%, 97.5% or 99% UCL on the mean concentration measured in non-culturally significant plant samples in wet weight. The dry weight non-culturally significant data were converted to wet weight using an average moisture content of 66 percent.

[d] The ILCR and HQ estimates were based on measured plant data, where available.

[e] Risk- and hazard-based cleanup levels are based on RME exposure assumptions and measured plant data, where available, and calculated for a chemical-specific ILCR and HQ of $1x10^{-4}$ and 1 as shown in Table A-3a and Table A-3b, respectively.

Bold indicates exceedence of the USEPA's risk management range and/or IDEQ's point of departure.

COC - chemical of concern
EPC - exposure point concentration
HQ - hazard quotient
IDEQ - Idaho Department of Environmental Quality
ILCR - incremental lifetime cancer risk
mg/kg - milligrams per kilogram
mg/L - milligrams per liter
NA - not applicable
na - not available
USEPA - U. S. Environmental Protection Agency
RME - reasonable maximum exposure
ILCR - incremental lifetime cancer risk

Table A-3a
Cancer Risk-Based Cleanup Level Calculation for Upland Soil - Fruits and Vegetables

COC	Upland Soil Concentration[a] (mg/kg)	Upland Soil Cleanup Level[b] (mg/kg)	Groundwater Concentration[a] (mg/L)	Modeled Fruit and Vegetable Concentration from Soil[c] (mg/kg)	Modeled Fruit and Vegetable Concentration from Groundwater (mg/kg)	Measured Non-Culturally Significant Plant Concentration[c] (mg/kg)	Total Fruit and Vegetable Concentration [d] (mg/kg)	Total Plant Ingestion Dose (mg/kg-d)	Cancer Slope Factor (mg/kg-d)$^{-1}$ [e] Oral	Chemical-Specific Risk
Arsenic	21.8	--	0.0119	5.89	0.158	0.506	0.664	1.5E-03	1.5E+00	**2.2E-03**
	--	1.29	NA	0.0299	NA	NA	0.0299	6.7E-05	1.5E+00	**1.0E-04**

Notes:

[a] The lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% UCL on the mean concentration measured in upland soil and groundwater samples collected from Ballard Mine sampling locations.

[b] The cancer risk-based upland soil cleanup level associated with RME exposures to fruits and vegetables was calculated based on measured plant data by replacing the modeled plant concentration based on published uptake factors with a modeled concentration based on measured data, as described below, and solving for the soil concentration that resulted in a chemical-specific cancer risk of $1x10^{-4}$.

[c] The literature-based modeled plant concentration was calculated as the wet soil to plant uptake plus mass loading factor multiplied by the soil concentration. For calculation of site-specific cleanup levels, the modeled plant concentration was calculated as the ratio of the measured plant concentration to the measured soil concentration, multiplied by the soil cleanup level that resulted in a chemical-specific cancer risk of $1x10^{-4}$.

[d] For an analyte that is only a chemical of potential concern (COPC) in soil, measured non-culturally significant plant concentration, when available, was used to represent the fruits and vegetables concentration. If an analyte is a COPCs in groundwater, the total fruits and vegetables concentration is equal to the modeled concentration from groundwater plus either the measured non-culturally significant plant concentration when available, or the modeled concentration from soil.

[e] Doses and risks shown only for carcinogenic chemicals with available toxicity values.

% UCL	percent upper confidence limit	mg/L	milligrams per liter
ILCR	incremental lifetime cancer risk	NA	not applicable
mg/kg	milligrams per kilogram	RME	reasonable maximum exposure
mg/kd-d	milligrams per kilogram per day		

Table A-3b
Noncancer Ha ard-Based Cleanup Level Calculations for Upland Soil - Fruits and Vegetables

COC	Upland Soil Concentration[a] (mg/kg)	Upland Soil Cleanup Level[b] (mg/kg)	Groundwater Concentration[a] (mg/L)	Modeled Fruit and Vegetable Concentration from Soil[c] (mg/kg)	Modeled Fruit and Vegetable Concentration from Groundwater (mg/kg)	Measured Non-Culturally Significant Plant Concentration[c] (mg/kg)	Total Fruit and Vegetable Concentration [d] (mg/kg)	Total Plant Ingestion Dose (mg/kg-d)	Reference Dose (mg/kg-d) [e] Oral	Chemical-Specific HQ
Antimony	4.89	--	NA	1.52	NA	na	1.52	7.9E-03	4.0E-04	**20**
	--	0.248	NA	0.0769	NA	NA	0.0769	4.0E-04	4.0E-04	1.0
Arsenic	21.8	--	0.0119	5.89	0.158	0.506	0.664	3.5E-03	3.0E-04	**12**
	--	2.49	NA	0.0576	NA	NA	0.0576	3.0E-04	3.0E-04	1.0
Cadmium	37.6	--	0.00195	14.5	0.0339	0.458	0.492	2.6E-03	1.0E-03	**2.6**
	--	15.8	NA	0.192	NA	NA	0.192	1.0E-03	1.0E-03	1.0
Molybdenum	20.0	--	NA	6.45	NA	7.32	7.32	3.8E-02	5.0E-03	**7.6**
	--	2.62	NA	0.961	NA	NA	0.961	5.0E-03	5.0E-03	1.0
Selenium	53.5	--	0.480	14.3	6.32	14.2	20.5	1.1E-01	5.0E-03	**21**
	--	3.62	NA	0.961	NA	NA	0.961	5.0E-03	5.0E-03	1.0
Thallium	1.20	--	0.000286	0.313	0.00370	0.0517	0.0554	2.9E-04	1.0E-05	**29**
	--	0.0447	NA	0.00192	NA	NA	0.00192	1.0E-05	1.0E-05	1.0
Uranium	38.3	--	NA	10.0	NA	0.0435	0.0435	2.3E-04	6.0E-04	0.38
	--	101	NA	0.115	NA	NA	0.115	6.0E-04	6.0E-04	1.0

Notes:

[a] The lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% UCL on the mean concentration measured in upland soil and groundwater samples collected from Ballard Mine sampling locations.

[b] The noncancer hazard-based upland soil cleanup level associated with RME exposures to fruits and vegetables was calculated based on measured plant data where available by replacing the modeled plant concentration based on published uptake factors with a modeled concentration based on measured data where available, as described below. The cleanup level is the soil concentration that results in a chemical-specific hazard of 1.

[c] The literature-based modeled plant concentration was calculated as the wet soil to plant uptake plus mass loading factor multiplied by the soil concentration. For calculation of site-specific cleanup levels, the modeled plant concentration was calculated as the ratio of the measured plant concentration to the measured soil concentration, multiplied by the soil cleanup level that resulted in a chemical-specific noncancer hazard of 1.

[d] For an analyte that is only a chemical of potential concern (COPC) in soil, measured non-culturally significant plant concentration, when available, was used to represent the fruits and vegetables concentration. If an analyte is a COPCs in groundwater, the total fruits and vegetables concentration is equal to the modeled concentration from groundwater plus either the measured non-culturally significant plant concentration when available, or the modeled concentration from soil.

[e] Doses and noncancer hazards shown only for noncarcinogenic chemicals with available toxicity values.

% UCL	percent upper confidence limit	mg/kd-d	milligrams per kilogram per day
COC	chemical of concern	mg/L	milligrams per liter
EPC	exposure point concentration	NA	not applicable
HQ	hazard quotient	na	not available
mg/kg	milligrams per kilogram	RME	reasonable maximum exposure

Table A-4
Summary of Risk-Based Cleanup Levels - Elk - Upland Soil

COC	Upland Soil EPC[a] (mg/kg)	Surface Water EPC[a] (mg/L)	Modeled Elk Concentration[b] (mg/kg)	Risk and Ha ard Estimates for the Current/Future Native American[b] (unitless)		Risk- and Ha ard-Based Cleanup Levels for the Current/Future Native American[c] (mg/kg)	
				ILCR	HQ	Risk-Based	Ha ard-Based
Antimony	10.9	NA	0.000291	NA	0.00022	NA	50,229
Arsenic	45.5	0.0556	0.003391	6.5E-07	0.0034	14,808	28,557
Cadmium	167	NA	0.00402	NA	0.0012	NA	139,359
Molybdenum	48.7	0.160	0.02407	NA	0.0014	NA	94,581
Selenium	209	2.84	0.738	NA	0.044	NA	66,688
Thallium	3.68	NA	0.00229	NA	0.068	NA	53.8
Uranium	87.1	0.0599	0.000468	NA	0.00023	NA	635,749

Notes:

[a] Elk tissue was evaluated in the Tier I risk assessment only; therefore the soil and surface water EPCs are equal to the maximum detected concentration measured in those media collected from Ballard Mine sampling locations.

[b] Modeled tissue concentration and cancer risk and noncancer hazard estimates shown here include contamination in tissue from surface water in addition to soil.

[c] Risk- and hazard-based cleanup levels were calculated for a chemical-specific ILCR and HQ of $1x10^{-4}$ and 1, respectively. The cleanup levels are calculated as the soil EPC divided by the ILCR multiplied by 10^{-4} and as the soil EPC divided by the HQ, as shown in Tables A-4a and A-4b, respectively.

Bold indicates exceedence of the USEPA's risk management range and/or IDEQ's point of departure.

COC - chemical of concern
EPC - exposure point concentration
HQ - hazard quotient
IDEQ - Idaho Department of Environmental Quality
ILCR - incremental lifetime cancer risk
mg/kg - milligrams per kilogarm
mg/L - milligrams per liter
NA - not applicable
USEPA - U. S. Environmental Protection Agency

Table A-4a
Cancer Risk-Based Cleanup Level Calculation for Upland Soil - Elk Tissue

Analyte	Upland Soil Concentration[a] (mg/kg)	Upland Soil Cleanup Level[b] (mg/kg)	Surface Water Concentration[a] (mg/L)	Modeled Elk Tissue Concentration from Soil (mg/kg)	Modeled Elk Tisse Concentration from Surface Water (mg/kg)	Total Elk Tissue Concentration (mg/kg)	Modeled Elk Ingestion Dose (mg/kg-d)	Cancer Slope Factor $(mg/kg\text{-}d)^{-1}$ [c] Oral	Chemical-Specific Risk
Arsenic	45.5	--	0.0556	0.00160	0.00179	0.00339	4.3E-07	1.5E+00	6.5E-07
	--	14,808	NA	0.521	NA	0.521	6.7E-05	1.5E+00	**1.0E-04**

Notes:

[a] Maximum detected concentration measured in upland soil and surface water samples collected from Ballard Mine sampling locations.

[b] The cancer risk-based upland soil cleanup level associated with RME exposures to elk tissue was calculated from the soil concentration only, as the EPC divided by the chemical specific risk for soil-based tissue uptake, multiplied by 0.0001.

[c] Doses and risks shown only for carcinogenic chemicals with available toxicity values.

EPC	exposure point concentration	mg/L	milligrams per liter
mg/kg	milligrams per kilogram	NA	not applicable
mg/kg-d	milligrams per kilogram per day	RME	reasonable maximum exposure

Table A-4b
Noncancer Risk-Based Cleanup Level Calculations for Upland Soil - Elk Tissue

Analyte	Upland Soil Concentration[a] (mg/kg)	Upland Soil Cleanup Level[b] (mg/kg)	Surface Water Concentration[a] (mg/L)	Modeled Elk Tissue Concentration from Soil (mg/kg)	Modeled Elk Tisse Concentration from Surface Water (mg/kg)	Total Elk Tissue Concentration (mg/kg)	Modeled Elk Ingestion Dose (mg/kg-d)	Reference Dose (mg/kg-d) [c] Oral	Chemical-Specific HQ
Antimony	10.9	--	NA	0.000291	NA	0.000291	8.7E-08	4.0E-04	0.00022
	--	50,229	NA	1.34	NA	1.34	4.0E-04	4.0E-04	1.0
Arsenic	45.5	--	0.0556	0.00160	0.00179	0.00339	1.0E-06	3.0E-04	0.0034
	--	28,557	NA	1.01	NA	1.01	3.0E-04	3.0E-04	1.0
Cadmium	167	--	NA	0.00402	NA	0.00402	1.2E-06	1.0E-03	0.0012
	--	139,359	NA	3.35	NA	3.35	1.0E-03	1.0E-03	1.0
Molybdenum	48.7	--	0.160	0.00863	0.0154	0.0241	7.2E-06	5.0E-03	0.0014
	--	94,581	NA	16.8	NA	16.8	5.0E-03	5.0E-03	1.0
Selenium	209	--	2.84	0.0525	0.685	0.738	2.2E-04	5.0E-03	0.044
	--	66,688	NA	16.8	NA	16.8	5.0E-03	5.0E-03	1.0
Thallium	3.68	--	NA	0.00229	NA	0.00229	6.8E-07	1.0E-05	0.068
	--	53.8	NA	0.0335	NA	0.0335	1.0E-05	1.0E-05	1.0
Uranium	87.1	--	0.0599	0.000276	0.000193	0.000468	1.4E-07	6.0E-04	0.00023
	--	635,749	NA	2.01	NA	2.01	6.0E-04	6.0E-04	1.0

Notes:

[a] Maximum detected concentration measured in upland soil and surface water samples collected from Ballard Mine sampling locations.

[b] The noncancer hazard-based upland soil cleanup level associated with RME exposures to elk tissue was calculated from the soil concentration only, as the EPC divided by the chemical specific hazard for soil-based tissue uptake.

[c] Doses and noncancer hazards shown only for chemicals with available toxicity values.

EPC	exposure point concentration	mg/L	milligrams per liter
HQ	hazard quotient	NA	not applicable
mg/kg	milligrams per kilogram	RME	reasonable maximum exposure
mg/kd-d	milligrams per kilogram per day		

Table A-5
Summary of Risk-Based Cleanup Levels for Upland Soil - Cattle Tissue

COC	Upland Soil EPC[a] (mg/kg)	Groundwater Concentration[a] (mg/L)	Modeled Cattle Concentration[b] (mg/kg)	Risk and Ha ard Estimates for the Current/Future Seasonal Rancher (unitless)		Risk- and Ha ard-Based Cleanup Levels for the Current/Future Seasonal Rancher[c] (mg/kg)	
				ILCR	HQ	Risk-Based	Ha ard-Based
Antimony	4.89	NA	0.00915	NA	0.15	NA	32.8
Arsenic	21.8	0.0119	0.0558	**1.9E-04**	**1.2**	11.9	18.4
Cadmium	37.6	0.00195	0.0628	NA	0.41	NA	92.1
Molybdenum	20.0	NA	0.248	NA	0.32	NA	62.0
Selenium	53.5	0.480	1.34	NA	**1.7**	NA	42.9
Thallium	1.20	0.000286	0.0540	NA	**35**	NA	0.0345
Uranium	38.3	NA	0.00864	NA	0.094	NA	408

Notes:

[a] The EPCs used to model cattle concentration is the lower of the maximum detected concentration or the ProUCL recommended 95%, 97.5% or 99% UCL on the mean concentration measured in upland soil and groundwater samples collected from Ballard Mine sampling locations.

[b] The cattle EPC used in the risk assessment was modeled from upland soil and groundwater EPCs.

[c] Risk- and hazard-based cleanup levels were calculated for a chemical-specific ILCR and HQ of $1x10^{-4}$ and 1, as shown in Tables 5a and 5b, respectively.

Bold indicates exceedence of the USEPA's risk management range and/or IDEQ's point of departure.

% UCL - percent upper confidence limit
COC - chemical of concern
EPC - exposure point concentration
HQ - hazard quotient
IDEQ - Idaho Department of Environmental Quality
ILCR - incremental lifetime cancer risk
mg/kg - milligrams per kilogram
mg/L - milligrams per liter
NA - not applicable
RME - reasonable maximum exposure
USEPA - U. S. Environmental Protection Agency

Table A-5a
Cancer Risk-Based Cleanup Level Calculation for Upland Soil - Cattle Tissue

COC	Upland Soil Concentration[a] (mg/kg)	Upland Soil Cleanup Level[b] (mg/kg)	Groundwater Concentration (mg/L)	Modeled Cattle Concentration from Soil (mg/kg)	Modeled Cattle Concentration from Groundwater (mg/kg)	Total Cattle Concentration (mg/kg)	Modeled Cattle Ingestion Dose (mg/kg-d)	Cancer Slope Factor $(mg/kg\text{-}d)^{-1}$ [c] Oral	Chemical-Specific Risk
Arsenic	21.8	--	0.0119	0.0546	0.00126	0.0558	1.2E-04	1.5E+00	**1.9E-04**
	--	11.9	NA	0.0298	NA	0.0298	6.7E-05	1.5E+00	**1.0E-04**

Notes:

[a] Maximum detected concentration or the ProUCL recommended 95%, 97.5% or 99% UCL on the mean concentration measured in upland soil and groundwater samples collected from Ballard Mine sampling locations.

[b] The cancer risk-based upland soil cleanup level associated with RME exposures to cattle tissue was calculated from the soil concentration only, as the EPC divided by the chemical specific risk for soil-based tissue uptake, multiplied by 0.0001.

[c] Doses and risks shown only for carcinogenic chemicals with available toxicity values.

% UCL	percent upper confidence limit	mg/kg-d	milligrams per kilogram per day
COC	chemical of concern	mg/L	milligrams per liter
ILCR	incremental lifetime cancer risk	NA	not applicable
mg/kg	milligrams per kilogram	RME	reasonable maximum exposure

Table A-5b
Noncancer Risk-Based Cleanup Level Calculations for Upland Soil - Cattle Tissue

COC	Upland Soil Concentration[a] (mg/kg)	Upland Soil Cleanup Level[b] (mg/kg)	Groundwater Concentration[a] (mg/L)	Modeled Cattle Concentration from Soil (mg/kg)	Modeled Cattle Concentration from Groundwater (mg/kg)	Total Cattle Concentration (mg/kg)	Modeled Cattle Ingestion Dose (mg/kg-d)	Reference Dose (mg/kg-d) [c] Oral	Chemical-Specific HQ
Antimony	4.89	--	NA	0.00915	NA	9.1E-03	6.0E-05	4.0E-04	0.15
	--	32.8	NA	0.0614	NA	6.1E-02	4.0E-04	4.0E-04	1.0
Arsenic	21.8	--	0.0119	0.0546	0.00126	5.6E-02	3.6E-04	3.0E-04	**1.2**
	--	18.4	NA	0.0460	NA	4.6E-02	3.0E-04	3.0E-04	1.0
Cadmium	37.6	--	0.00195	0.0627	0.0000568	6.3E-02	4.1E-04	1.0E-03	0.41
	--	92.1	NA	0.153	NA	1.5E-01	1.0E-03	1.0E-03	1.0
Molybdenum	20.0	--	NA	0.248	NA	2.5E-01	1.6E-03	5.0E-03	0.32
	--	62.0	NA	0.767	NA	7.7E-01	5.0E-03	5.0E-03	1.0
Selenium	53.5	--	0.4800	0.957	0.382	1.3E+00	8.7E-03	5.0E-03	**1.7**
	--	42.9	NA	0.767	NA	7.7E-01	5.0E-03	5.0E-03	1.0
Thallium	1.20	--	0.000286	0.0534	0.000605	5.4E-02	3.5E-04	1.0E-05	**35**
	--	0.0345	NA	0.00153	NA	1.5E-03	1.0E-05	1.0E-05	1.0
Uranium	38.3	--	NA	0.00864	NA	8.6E-03	5.6E-05	6.0E-04	0.094
	--	408	NA	0.0921	NA	9.2E-02	6.0E-04	6.0E-04	1.0

Notes:

[a] Maximum detected concentration or the ProUCL recommended 95%, 97.5% or 99% UCL on the mean concentration measured in upland soil and groundwater samples collected from Ballard Mine sampling locations.

[b] The noncancer hazard-based upland soil cleanup level associated with RME exposures to cattle tissue was calculated from the soil concentration only, as the EPC divided by the chemical specific hazard for soil-based tissue uptake.

[c] Doses and noncancer hazards shown only for noncarcinogenic chemicals with available toxicity values.

% UCL	percent upper confidence limit
COC	chemical of concern
EPC	exposure point concentration
HQ	hazard quotient
mg/kg	milligrams per kilogram
mg/kd-d	milligrams per kilogram per day
mg/L	milligrams per liter
NA	not applicable
RME	reasonable maximum exposure

Table A-6
Summary of Risk-Based Cleanup Levels for Riparian Soil   Direct Contact

COC	Riparian Soil EPC[a] (mg/kg)	Risk and Ha ard Estimates for the Current/Future Native American (unitless)		Risk- and Ha ard-Based Cleanup Levels for the Current/Future Native American[b] (mg/kg)	
		ILCR	HQ	Risk-Based	Ha ard-Based
Arsenic	5.83	**1.1E-05**	0.057	53.3	103
Cadmium	25.4	1.9E-10	0.11	NA[c]	230
Molybdenum	16.4	NA	0.011	NA	1,562
Nickel	281	3.0E-10	0.17	NA[c]	1,612
Selenium	89.5	NA	0.073	NA	1,221
Thallium	0.376	NA	0.12	NA	3.12
Vanadium	233	NA	0.82	NA	285

Notes:

[a] The exposure point concentration (EPC) is the lower of the maximum detected concentration or 95%, 97.5% or 99% UCL on the mean concentration measured in riparian soil samples collected from Ballard Mine sampling locations.

[b] Risk- and hazard-based cleanup levels are calculated for a chemical-specific ILCR and HQ of $1x10^{-4}$ and 1, respectively. Cancer-based cleanup levels are calculated as the EPC divided by the ILCR multiplied by 10^{-4}; noncancer hazard-based cleanup levels are calculated as the EPC divided by the HQ.

[c] Risk-based cleanup level exceeds 1,000,000 milligrams per kilogram - health effects are negligible.

Bold indicates exceedence of the USEPA's risk management range and/or IDEQ's point of departure.

% UCL - percent upper confidence limit
COC - chemical of concern
EPC - exposure point concentration
HQ - hazard quotient
IDEQ - Idaho Department of Environmental Quality
ILCR - incremental lifetime cancer risk
mg/kg - milligrams per kilogarm
NA - not applicable
USEPA - U. S. Environmental Protection Agency

Table A-7

Summary of Risk-Based Cleanup Levels for Riparian Soil   Culturally Significant Plants

COC	Riparian Soil EPC[a] (mg/kg)	Modeled Culturally Significant Plant Concentration[b] (mg/kg)	Measured Riparian Plant Concentration[c] (mg/kg)	Risk and Ha ard Estimates for the Current/Future Native American[d] (unitless)		Risk- and Ha ard-Based Cleanup Levels for the Current/Future Native American[e] (mg/kg)	
				ILCR	**HQ**	**Risk-Based**	**Ha ard-Based**
Arsenic	5.83	1.57	na	**5.3E-03**	**27**	0.111	0.213
Cadmium	25.4	9.76	0.651	NA	**3.4**	NA	7.48
Molybdenum	16.4	5.30	4.88	NA	**5.1**	NA	3.23
Nickel	281	77.2	na	NA	**20**	NA	14.0
Selenium	89.5	23.8	5.47	NA	**5.7**	NA	15.7
Thallium	0.376	0.0981	na	NA	**51**	NA	0.00736
Vanadium	233	60.9	na	NA	**63**	NA	3.68

Notes:

[a] The lower of the maximum detected concentration and ProUCL recommended 95%, 97.5% or 99% UCL on the mean concentration measured in Riparian Soil samples collected from Ballard Mine sampling locations.

[b] The modeled culturally significant plants EPC shown here was calculated from the riparian soil EPC using soil-to-plant uptake factors.

[c] The lower of the maximum detected concentration and ProUCL recommended 95%, 97.5% or 99% UCL on the mean concentration measured in riparian plant samples in wet weight. The dry weight riparian plant data were converted to wet weight using an average moisture content of 66 percent.

[d] The ILCR and HQ estimates were based on measured plant data, where available.

[e] Risk- and hazard-based cleanup levels are based on RME exposure assumptions and measured plant data, where available, and calculated for a chemical-specific ILCR and HQ of $1x10^{-4}$ and 1 as shown in Table A-7a and Table A-7b, respectively.

Bold indicates exceedence of the USEPA's risk management range and/or IDEQ's point of departure.

% UCL - percent upper confidence limit
COC - chemical of concern
EPC - exposure point concentration
HQ - hazard quotient
IDEQ - Idaho Department of Environmental Quality
ILCR - incremental lifetime cancer risk
mg/kg - milligrams per kilogarm
NA - not applicable
na - not available
RME - reasonable maximum exposure
USEPA - U. S. Environmental Protection Agency

Table A-7a
Cancer Risk-Based Cleanup Level Calculation for Riparian Soil - Culturally Significant Plants

COC	Riparian Soil Concentration[a] (mg/kg)	Riparian Soil Cleanup Level[b] (mg/kg)	Modeled Culturally Significant Plant Concentration from Soil[c] (mg/kg)	Measured Riparian Plant Concentration (mg/kg)	Modeled Plant Ingestion Dose (mg/kg-d)	Measured Plant Ingestion Dose (mg/kg-d)	Cancer Slope Factor $(mg/kg\text{-}d)^{-1}$ [d]	Pathway-Specific Cancer Risk		Chemical-Specific Risk
							Oral	Modeled Plant Ingestion	Measured Plant Ingestion	
Arsenic	5.83	--	1.57	na	3.5E-03	NA	1.5E+00	5.3E-03	na	**5.3E-03**
	--	0.111	0.0299	NA	6.7E-05	NA	1.5E+00	1.0E-04	na	**1.0E-04**

Notes:

[a] The lower of the maximum detected concentration and ProUCL recommended 95%, 97.5% or 99% UCL on the mean concentration measured in Riparian Soil samples collected from Ballard Mine sampling locations.

[b] The cancer risk-based riparian soil cleanup level associated with RME exposures to riparian culturally significant plants was calculated using a modeled plant concentration based on published uptake factors and solving for the soil concentration that resulted in a chemical-specific cancer risk of $1x10^{-4}$ because measured data were not available for arsenic in riparian culturally significant plants.

[c] The literature-based modeled plant concentration was calculated as the wet soil to plant uptake plus mass loading factor multiplied by the soil concentration.

[d] Doses and risks shown only for carcinogenic chemicals with available toxicity values.

% UCL	percent upper confidence limit	mg/kg-d	milligrams per kilogram per day
COC	chemical of concern	NA	not applicable
ILCR	incremental lifetime cancer risk	na	not available
mg/kg	milligrams per kilogram	RME	reasonable maximum exposure

Table A-7b
Noncancer Risk-Based Cleanup Level Calculations for Riparian Soil - Culturally Significant Plants

COC	Riparian Soil Concentration[a] (mg/kg)	Riparian Soil Cleanup Level[b] (mg/kg)	Modeled Culturally Significant Plant Concentration from Soil[c] (mg/kg)	Measured Culturally Significant Plant Concentration (mg/kg)	Modeled Plant Ingestion Dose (mg/kg-d)	Measured Plant Ingestion Dose (mg/kg-d)	Reference Dose (mg/kg-d) [d] Oral	Pathway-Specific Ha ard: Modeled Plant Ingestion	Pathway-Specific Ha ard: Measured Plant Ingestion	Chemical-Specific HQ [e]
Arsenic	5.83	--	1.57	na	8.2E-03	na	3.0E-04	27	na	**27**
	--	0.213	0.0576	NA	3.0E-04	NA	3.0E-04	1.0	na	1.0
Cadmium	25.4	--	9.76	0.65	5.1E-02	3.4E-03	1.0E-03	51	3.4	**3.4**
	--	7.48	0.192	NA	1.0E-03	NA	1.0E-03	1.0	na	1.0
Molybdenum	16.4	--	5.30	4.88	2.8E-02	2.5E-02	5.0E-03	5.5	5.1	**5.1**
	--	3.23	0.961	NA	5.0E-03	NA	5.0E-03	1.0	na	1.0
Nickel	281	--	77.2	na	4.0E-01	na	2.0E-02	20	na	**20**
	--	14.0	3.84	NA	2.0E-02	NA	2.0E-02	1.0	na	1.0
Selenium	89.5	--	23.8	5.47	1.2E-01	2.8E-02	5.0E-03	25	5.7	**5.7**
	--	15.7	0.961	NA	5.0E-03	NA	5.0E-03	1.0	na	1.0
Thallium	0.376	--	0.0981	na	5.1E-04	na	1.0E-05	51	na	**51**
	--	0.00736	0.00192	NA	1.0E-05	NA	1.0E-05	1.0	na	1.0
Vanadium	233	--	60.9	na	3.2E-01	na	5.0E-03	63	na	**63**
	--	3.68	0.961	NA	5.0E-03	NA	5.0E-03	1.0	na	1.0

Notes:

[a] The lower of the maximum detected concentration and ProUCL recommended 95%, 97.5% or 99% UCL on the mean concentration measured in Riparian Soil samples collected from Ballard Mine sampling locations.

[b] The noncancer hazard-based riparian soil cleanup level associated with RME exposures to riparian culturally significant plants was calculated based on measured plant data where available, as described below. The cleanup level is the soil concentration that results in a chemical-specific hazard of 1.

[c] The literature-based modeled plant concentration was calculated as the wet soil to plant uptake plus mass loading factor multiplied by the soil concentration. For calculation of site-specific cleanup levels, the modeled plant concentration was calculated as the ratio of the measured plant concentration to the measured soil concentration, multiplied by the soil cleanup level that resulted in a chemical-specific noncancer hazard of 1.

[d] Doses and noncancer hazards shown only for noncarcinogenic chemicals with available toxicity values.

[e] Measured riparian culturally significant plant data were used when available.

% UCL	percent upper confidence limit	mg/kd-d	milligrams per kilogram per day
COC	chemical of concern	NA	not applicable
EPC	exposure point concentration	na	not available
HQ	hazard quotient	RME	reasonable maximum exposure
mg/kg	milligrams per kilogram		

Table A-8
Summary of Risk-Based Cleanup Levels for Sediment   Culturally Significant Aquatic Plants

COC	Sediment EPC[a] (mg/kg)	Surface Water EPC[a] (mg/kg)	Modeled Culturally Significant Aquatic Plant Concentration[b] (mg/kg)	Risk and Ha ard Estimates for the Current/Future Native American (unitless)		Risk- and Ha ard-Based Cleanup Levels for the Current/Future Native American[c] (mg/kg)	
				ILCR	HQ	Risk-Based	Ha ard-Based
Arsenic	13.0	0.0123	0.167	**5.6E-04**	**2.9**	2.33	4.49
Cadmium	42.1	NA	1.64	NA	**8.5**	NA	0.828
Selenium	208	0.506	63.2	NA	**66**	NA	4.70

Notes:

[a] The EPCs used to model culturally significant aquatic plants concentration is the lower of the maximum detected concentration or the 95% UCL on the mean concentration measured in sediment or surface water samples collected from Ballard Mine sampling locations.

[b] The culturally significant aquatic plants EPCs for surface water chemicals of potential concern were modeled from the sediment EPCs using sediment-to-plant uptake factors when sediment data were available.

[c] Risk- and hazard-based cleanup levels were calculated for a chemical-specific ILCR and HQ of $1x10^{-4}$ and 1, respectively. Sediment to aquatic plant uptake regressions for some metals, including cadmium and selenium are not linear, and therefore risk-based cleanup levels for were determined numerically using the Solver tool in Excel, as shown in Tables A-8a and A-8b.

Bold indicates exceedence of the USEPA's risk management range and/or IDEQ's point of departure.

% UCL - percent upper confidence limit
EPC - exposure point concentration
COC - chemical of concern
HQ - hazard quotient
IDEQ - Idaho Department of Environmental Quality
ILCR - incremental lifetime cancer risk
mg/kg - milligrams per kilogarm
mg/L - milligrams per liter
NA - not applicable
na - not available
USEPA - U. S. Environmental Protection Agency
RME - reasonable maximum exposure

Table A-8a
Cancer Risk-Based Cleanup Level Calculation for Sediment - Culturally Significant Aquatic Plants

COC	Sediment Concentration[a] (mg/kg)	Sediment Cleanup Level[b] (mg/kg)	Surface Water Concentration[a] (mg/L)	Modeled Culturally Significant Aquatic Plant Concentration from Sediment (mg/kg dry weight)	Modeled Culturally Significant Aquatic Plant Concentration from Sediment [c] (mg/kg wet weight)	Modeled Plant Ingestion Dose (mg/kg-d)	Cancer Slope Factor $(mg/kg\text{-}d)^{-1}$ [d] Oral	Chemical-Specific Risk
Arsenic	13.0	--	0.0123	0.489	0.167	3.7E-04	1.5E+00	**5.6E-04**
	--	2.33	NA	0.0873	0.0299	6.7E-05	1.5E+00	**1.0E-04**

Notes:

[a] Maximum detected concentration or 95% UCL on the mean concentration measured in sediment or surface water samples collected from Ballard Mine sampling locations.

[b] Cancer risk-based cleanup level for arsenic modeled using a linear sediment to plant uptake factor and calculated as the EPC divided by the ILCR, multiplied by the target risk of 0.0001.

[c] Dry weight plant concentrations were converted to wet weight plant concentrations assuming a plant moisture content of 65.7 percent.

[d] Doses and risks shown only for carcinogenic chemicals with available toxicity values.

95% UCL	95 percent upper confidence limit	mg/kg-d	milligrams per kilogram per day
COC	chemical of concern	mg/L	milligrams per liter
ILCR	incremental lifetime cancer risk	NA	not applicable
mg/kg	milligrams per kilogram	RME	reasonable maximum exposure
mg/kg-d	milligrams per kilogram per day		

Table A-8b
Noncancer Risk-Based Cleanup Level Calculations for Sediment - Culturally Significant Aquatic Plants

COC	Sediment Concentration[a] (mg/kg)	Sediment Cleanup Level[b] (mg/kg)	Surface Water Concentration[a] (mg/L)	Modeled Culturally Significant Aquatic Plant Concentration from Sediment	Modeled Culturally Significant Aquatic Plant Concentration from Sediment [c] (mg/kg wet weight)	Modeled Plant Ingestion Dose (mg/kg-d)	Reference Dose (mg/kg-d) [d] Oral	Chemical-Specific HQ
Arsenic	13.0	--	0.0123	0.489	0.167	8.7E-04	3.0E-04	**2.9**
	--	4.49	NA	0.168	0.0576	3.0E-04	3.0E-04	1.0
Cadmium	42.1	--	NA	4.79	1.64	8.5E-03	1.0E-03	**8.5**
	--	0.828	NA	0.561	0.192	1.0E-03	1.0E-03	1.0
Selenium	208	--	0.506	185	63.2	3.3E-01	5.0E-03	**66**
	--	4.70	NA	2.81	0.961	5.0E-03	5.0E-03	1.0

Notes:

[a] Maximum detected concentration or 95% UCL on the mean concentration measured in sediment or surface water samples collected from Ballard Mine sampling locations.

[b] Noncancer hazard-based cleanup level for arsenic modeled using a linear sediment to plant uptake factor and calculated as the EPC divided by the HQ. Noncancer hazard-based cleanup levels for cadmium and selenium modeled using nonlinear sediment to plant uptake factors and calculated with the Solver tool in Excel.

[c] Dry weight plant concentrations were converted to wet weight plant concentrations assuming a plant moisture content of 65.7 percent.

[d] Doses and noncancer hazards shown only for noncarcinogenic chemicals with available toxicity values.

95%	95 percent upper confidence limit	mg/kd-d	milligrams per kilogram per day
EPC	exposure point concentration	mg/L	milligrams per liter
HQ	hazard quotient	NA	not applicable
mg/k	milligrams per kilogram		

Table A-9
Summary of Risk-Based Cleanup Levels for Radium-226 in Upland Soil

	Risk-Based Cleanup Levels[a] (pCi/g) for:				
Radium-226	**Current /Future Native American**	**Hypothetical Future Resident**	**Current /Future Seasonal Rancher**	**Current /Future Recreational Hunter**	**Current/Future Camper Hiker**
Direct Exposure	6.24	6.24	7.42	13.0	20.8
Ingestion of Soil	153	153	515	4,420	5,900
External Exposure	6.50	6.50	7.53	13.0	20.9
Dust Inhalation	1,940,000	1,940,000	409,000	3,510,000	6,250,000
Upland Plant Tissue	0.254	0.254	NA	NA	NA
Elk Tissue	11,200	NA	NA	2,370	NA
Cattle Tissue	NA	NA	20.0	NA	NA
Cumulative	0.244	0.244	5.41	12.9	20.8

Notes:
[a] Calculated using the USEPA's online Preliminary Remediation Goal calculator, as described in MWH (2105).

NA - not applicable
pCi/g - picoCuries per gram

Table A-10
Upland Soil Risk-Based Cleanup Levels for Human Health

Upland Soil COC	Current/Future Native American			
	Direct Exposure	Upland Plant	Elk	**Cumulative**
Antimony	74.4	0.248	50,229	0.247
Arsenic	53.3	1.34	14,808	1.31
Cadmium	230	9.35	139,359	8.99
Molybdenum	1,562	31.6	94,581	31.0
Radium-226[a]	6.24	0.254	11,200	0.244
Selenium	1,221	1.23	66,688	1.23
Thallium	3.12	0.468	53.8	0.404
Uranium	187	44.2	635,749	35.7

	Hypothetical Future Resident		
	Direct Exposure	Upland Plant	**Cumulative**
Antimony	74.4	0.248	0.247
Arsenic	53.3	1.29	1.26
Cadmium	230	15.8	14.8
Molybdenum	1,562	2.62	2.62
Radium-226[a]	6.24	0.254	0.244
Selenium	1,221	3.62	3.61
Thallium	3.12	0.0447	0.0440
Uranium	187	101	65.8

	Current/Future Seasonal Rancher		
	Direct Exposure	Cattle Tissue	**Cumulative**
Antimony	194	32.8	28.1
Arsenic	186	11.9	11.2
Cadmium	698	92.1	81.4
Molybdenum	7,054	62.0	61.5
Radium-226[a]	7.42	20.0	5.41
Selenium	3,947	42.9	42.4
Thallium	14.1	0.0345	0.0345
Uranium	845	408	275

	Current/Future Recreational Hunter			Current/Future Camper/Hiker	
	Direct Exposure	Elk	**Cumulative**	Direct Exposure	**Cumulative**
Antimony	3,425	NA[b]	3,425	2,912	2,912
Arsenic	3,104	NA[b]	3,104	2,074	2,074
Cadmium	10,801	NA[b]	10,801	8,861	8,861
Molybdenum	78,011	NA[b]	78,011	59,092	59,092
Radium-226[a]	13.0	NA[b]	13.0	20.8	0.208
Selenium	58,280	NA[b]	58,280	47,017	47,017
Thallium	156	NA[b]	156	118	118
Uranium	9,348	NA[b]	9,348	7,087	7,087

Notes

All concentrations are in units of milligrams per kilograms (mg/kg) except for radium-226, which is an activity of picocuries per gram (pCi/g).

COC - chemical of concern

NA - not applicable

[a] Direct exposure to radium-226 includes external exposure to radiation, in addition to incidental ingestion of soil and inhalation of soil particulates.

[b] Elk consumption was not evaluated for the current/future recreational hunter because this receptor was evaluated in the Tier II risk assessment only, and elk tissue was determined not to be a medium of concern in the Tier I risk assessment.

Table A-11
Riparian Soil and Sediment Risk-Based Cleanup Levels for Human Health

Riparian Soil COC	Current/Future Native American		
	Direct Exposure	Riparian Plant	**Cumulative**
Arsenic	53.3	0.111	0.110
Cadmium	230	7.48	7.24
Molybdenum	1,562	3.23	3.23
Nickel	1,612	14.0	13.9
Selenium	1,221	15.7	15.5
Thallium	3.12	0.00736	0.00734
Vanadium	285	3.68	3.63
	Current/Future Native American		
Sediment COC	Aquatic Plants	**Cumulative**	
Arsenic	2.33	2.33	
Cadmium	0.828	0.828	
Selenium	4.70	4.70	

Notes

All concentrations are in units of milligrams per kilograms (mg/kg).

COC - chemical of concern

Table A-12
Ecological Risk-Based Cleanup Level Calculations for Upland Soil - Long-Tailed Vole

	EPC [a]		ERBCL			EPC	Measured Plant	Ingestion	TRV	Ecological
	$C_{UP\ SOIL}$	C_{WATER}	$C_{UP\ SOIL}$	BAF_{S-P} [b]	BAF_{S-P} [b]	C_{PLANT} [c]	Concentration [d]	Dose [e]	NOAEL	Ha ard
COEC	(mg/kg)	(mg/L)	(mg/kg)		(site-specific)	(mg/kg)	(mg/kg)	(mg/kg-day)	(mg/kg-day)	High
Antimony	4.89	NA	3.15	Regression	NA	0.116	NA	5.9E-02	5.9E-02	1.0
Cadmium	37.6	0.00440	38.2	Regression	0.0413	1.58	1.55	7.7E-01	7.7E-01	1.0
Chromium, total	327	NA	247	0.041	0.00741	1.83	2.42	2.4E+00	2.4E+00	1.0
Copper	87.2	0.380	195	Regression	0.0689	13.5	6.01	5.6E+00	5.6E+00	1.0
Molybdenum	20.0	NA	0.895	0.25	0.917	0.821	18.3	2.6E-01	2.6E-01	1.0
Nickel	205	NA	112	Regression	0.0252	2.82	5.18	1.7E+00	1.7E+00	1.0
Selenium	53.5	2.84	0.605	Regression	0.741	0.449	39.7	1.4E-01	1.4E-01	1.0
Thallium	1.20	NA	0.0884	0.0040	0.112	0.00986	0.134	3.7E-03	3.7E-03	1.0
Vanadium	239	0.0430	483	0.00485	0.00387	1.87	0.925	4.2E+00	4.2E+00	1.0
Zinc	835	NA	2,562	Regression	0.0713	183	59.6	7.5E+01	7.5E+01	1.0

Notes:

BAF_{S-P} - bioaccumulation factor from soil to plants
C_{UP_SOIL} - Upland Soil Concentration
C_{WATER} - Surface Water Concentration
COEC - chemical of ecological concern
EPC - exposure point concentration
ERBCL - ecological risk based cleanup level
HI - hazard index
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
mg/kg - milligrams per kilogram
mg/kg-day - milligrams per kilogram per day
mg/L - milligrams per liter
NA - not applicable
NOAEL - no observed adverse effects level
TRV - toxicity reference value

Exposure Parameters

Body Weight:		0.037	kg
Food Ingestion Rate (FIR):		0.0115	kg (dry wt)/day
	FIR_Plants (100%):	0.0115	kg (dry wt)/day
	FIR_Soil (2.4%):	0.00028	kg (dry wt)/day
Water Ingestion Rate:		0	L/day
Exposure Duration (ED):		1	unitless
Site Utilization Factor (SUF):		1	unitless
	Home range:	0.066	acres
	Exposure area:	412	acres

[a] The abiotic media exposure point concentrations used in the Tier II Ecological Risk Assessment are equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration measured in samples collected from the Ballard Mine.

[b] The soil-to-plant bioaccumulation factor was derived from sources listed in Table 4-15 and 4-16 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop. The site-specific soil-to-plant bioaccumulation factor, where available, is equal to the measured plant concentration divided by the measured soil concentration.

[c] The plant concentration (C_{PLANT}) was calculated from the upland soil concentration and the soil-to-plant bioconcentration factor (BCF_{S-P}).

[d] The measured plant concentration is equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration detected in plant tissue collected from Ballard Mine.

[e] The ingestion dose for the long-tailed vole accounts for exposure to soil based upon terrestrial foraging habits as presented in Table 4-17 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop, and uses measured plant tissue concentrations, where available, in preference to plant tissue concentrations modeled from upland soil.

Table A-13
Ecological Risk-Based Cleanup Level Calculations for Upland Soil - Elk

COEC	EPC [a] $C_{UP\ SOIL}$ (mg/kg)	EPC [a] C_{WATER} (mg/L)	ERBCL $C_{UP\ SOIL}$ (mg/kg)	BAF_{S-P} [b]	BAF_{S-P} [b] (site-specific)	EPC C_{PLANT} [c] (mg/kg)	Measured Plant Concentration [d] (mg/kg)	Ingestion Dose [e] (mg/kg-day)	TRV NOAEL (mg/kg-day)	Ecological Ha ard High
Antimony	4.89	NA	6,943	Regression	NA	158	NA	5.9E-02	5.9E-02	1.0
Cadmium	37.6	0.00440	63,265	Regression	0.0413	2,612	1.55	7.7E-01	7.7E-01	1.0
Chromium, total	327	NA	440,862	0.041	0.00741	3,268	2.42	2.4E+00	2.4E+00	1.0
Copper	87.2	0.380	317,302	Regression	0.0689	21,852	6.01	5.6E+00	5.6E+00	1.0
Molybdenum	20.0	NA	1,398	0.25	0.917	1,281	18.3	2.6E-01	2.6E-01	1.0
Nickel	205	NA	189,385	Regression	0.0252	4,772	5.18	1.7E+00	1.7E+00	1.0
Selenium	53.5	2.84	946	Regression	0.741	701	39.7	1.4E-01	1.4E-01	1.0
Thallium	1.20	NA	142	0.0040	0.112	15.8	0.134	3.7E-03	3.7E-03	1.0
Vanadium	239	0.0430	877,540	0.00485	0.00387	3,396	0.925	4.2E+00	4.2E+00	1.0
Zinc	835	NA	NA[f]	Regression	0.0713	NA	59.6	NA	7.5E+01	NA

Notes:

BAF_{S-P} - bioaccumulation factor from soil to plants
C_{UP_SOIL} - Upland Soil Concentration
C_{WATER} - Surface Water Concentration
COEC - chemical of ecological concern
EPC - exposure point concentration
ERBCL - ecological risk-based cleanup level
HI - hazard index
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
mg/kg - milligrams per kilogram
mg/kg-day - milligrams per kilogram per day
mg/L - milligrams per liter
NA - not applicable
NOAEL - no observed adverse effects level
TRV - toxicity reference value

Exposure Parameters

Body Weight:		286	kg
Food Ingestion Rate (FIR):		2.29	kg (dry wt)/day
	FIR_Plants (100%):	2.29	kg (dry wt)/day
	FIR_Soil (2%):	0.0459	kg (dry wt)/day
Water Ingestion Rate:		0	L/day
Exposure Duration (ED):		1	unitless
Site Utilization Factor (SUF):		0.0248	unitless
	Home range:	16,640	acres
	Exposure area:	412	acres

[a] The abiotic media exposure point concentrations used in the Tier II Ecological Risk Assessment are equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration measured in samples collected from the Ballard Mine.

[b] The soil-to-plant bioaccumulation factor was derived from sources listed in Table 4-15 and 4-16 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop. The site-specific soil-to-plant bioaccumulation factor, where available, is equal to the measured plant concentration divided by the measured soil concentration.

[c] The plant concentration (C_{PLANT}) was calculated from the upland soil concentration and the soil-to-plant bioconcentration factor (BCF_{S-P}).

[d] The measured plant concentration is equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration detected in plant tissue collected from Ballard Mine.

[e] The ingestion dose for the Elk accounts for exposure to soil based upon terrestrial foraging habits as presented in Table 4-17 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop, and uses measured plant tissue concentrations, where available, in preference to plant tissue concentrations modeled from upland soil.

[f] Concentration exceeds $1x10^{-6}$ milligrams per kilogram.

Table A-14
Ecological Risk-Based Cleanup Level Calculations for Upland Soil - American Goldfinch

	EPC [a]		ERBCL	BAF_{S-P} [b]		EPC	Measured Plant	Ingestion	TRV	Ecological
	$C_{UP\ SOIL}$	C_{WATER}	$C_{UP\ SOIL}$		BAF_{S-P} [b]	C_{PLANT} [c]	Concentration [d]	Dose [e]	NOAEL	Ha ard
COEC	**(mg/kg)**	**(mg/L)**	**(mg/kg)**		(site-specific)	**(mg/kg)**	**(mg/kg)**	**(mg/kg-day)**	**(mg/kg-day)**	**High**
Antimony	4.89	NA	--	Regression	na	--	na	--	--	--
Cadmium	37.6	0.00440	38.2	Regression	0.0413	1.58	1.55	1.5E+00	1.5E+00	1.0
Chromium, total	327	NA	90.4	0.041	0.00741	0.670	2.42	2.7E+00	2.7E+00	1.0
Copper	87.2	0.380	88.7	Regression	0.0689	6.11	6.01	4.1E+00	4.1E+00	1.0
Molybdenum	20.0	NA	13.0	0.25	0.917	11.9	18.3	3.5E+00	3.5E+00	1.0
Nickel	205	NA	197	Regression	0.0252	4.95	5.18	6.7E+00	6.7E+00	1.0
Selenium	53.5	2.84	1.30	Regression	0.741	0.962	39.7	2.9E-01	2.9E-01	1.0
Thallium	1.20	NA	6.07	0.0040	0.112	0.678	0.134	3.5E-01	3.5E-01	1.0
Vanadium	239	0.0430	12.1	0.00485	0.00387	0.0467	0.925	3.4E-01	3.4E-01	1.0
Zinc	835	NA	1,426	Regression	0.0713	102	59.6	6.6E+01	6.6E+01	1.0

Notes:
-- not available
BAF_{S-P} - bioaccumulation factor from soil to plants
C_{UP_SOIL} - Upland Soil Concentration
C_{WATER} - Surface Water Concentration
COEC - chemical of ecological concern
EPC - exposure point concentration
ERBCL - ecological risk-based cleanup level
HI - hazard index
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
mg/kg - milligrams per kilogram
mg/kg-day - milligrams per kilogram per day
mg/L - milligrams per liter
NA - not applicable
NOAEL - no observed adverse effects level
TRV - toxicity reference value

Exposure Parameters

Body Weight:		0.0155	kg
Food Ingestion Rate (FIR):		0.00410	kg (dry wt)/day
	FIR_Plants (100%):	0.00410	kg (dry wt)/day
	FIR_Soil (10.4%):	0.000426	kg (dry wt)/day
Water Ingestion Rate:		0	L/day
Exposure Duration (ED):		1	unitless
Site Utilization Factor (SUF):		1	unitless
	Home range:	0.119	acres
	Exposure area:	412	acres

[a] The abiotic media exposure point concentrations used in the Tier II Ecological Risk Assessment are equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration measured in samples collected from the Ballard Mine.

[b] The soil-to-plant bioaccumulation factor was derived from sources listed in Table 4-15 and 4-16 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop. The site-specific soil-to-plant bioaccumulation factor, where available, is equal to the measured plant concentration divided by the measured soil concentration.

[c] The plant concentration (C_{PLANT}) was calculated from the upland soil concentration and the soil-to-plant bioconcentration factor (BCF_{S-P}).

[d] The measured plant concentration is equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration detected in plant tissue collected from Ballard Mine.

[e] The ingestion dose for the accounts for exposure to soil based upon terrestrial foraging habits as presented in Table 4-17 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop, and uses measured plant tissue concentrations, where available, in preference to plant tissue concentrations modeled from upland soil.

Table A-15
Ecological Risk-Based Cleanup Level Calculations for Upland Soil - Deer Mouse

COEC	EPC [a] $C_{UP\ SOIL}$ (mg/kg)	EPC [a] C_{WATER} (mg/L)	ERBCL $C_{UP\ SOIL}$ (mg/kg)	$BAF_{S\text{-}P}$ [b]	$BAF_{S\text{-}P}$ [b] (site-specific)	EPC C_{PLANT} [c] (mg/kg)	Measured Plant Concentration [d] (mg/kg)	$BAF_{S\text{-}I}$ [b]	EPC C_{INVERT} [c] (mg/kg)	Ingestion Dose [e] (mg/kg-day)	TRV NOAEL (mg/kg-day)	Ecological Ha ard High
Antimony	4.89	NA	0.703	Regression	na	0.0283	na	1	0.703	5.9E-02	5.9E-02	1.0
Cadmium	37.6	0.00440	1.28	Regression	0.0413	0.0529	1.55	Regression	10.1	7.7E-01	7.7E-01	1.0
Chromium, total	327	NA	86.3	0.041	0.0074	0.639	2.42	0.3060	26.4	2.4E+00	2.4E+00	1.0
Copper	87.2	0.380	110	Regression	0.0689	7.57	6.01	0.515	56.6	5.6E+00	5.6E+00	1.0
Molybdenum	20.0	NA	1.37	0.25	0.9165	1.26	18.3	1	1.37	2.6E-01	2.6E-01	1.0
Nickel	205	NA	20.7	Regression	0.0252	0.521	5.18	1	20.7	1.7E+00	1.7E+00	1.0
Selenium	53.5	2.84	0.864	Regression	0.7415	0.640	39.7	Regression	0.833	1.4E-01	1.4E-01	1.0
Thallium	1.20	NA	0.0400	0.0040	0.1116	0.00446	0.134	1	0.0400	3.7E-03	3.7E-03	1.0
Vanadium	239	0.0430	552	0.00485	0.0039	2.138	0.925	0.042	23.2	4.2E+00	4.2E+00	1.0
Zinc	835	NA	1,028	Regression	0.0713	73.3	59.6	Regression	832	7.5E+01	7.5E+01	1.0

Notes:

$BAF_{S\text{-}I}$ - bioaccumulation factor from soil to invertebrates
$BAF_{S\text{-}P}$ - bioaccumulation factor from soil to plants
C_{UP_SOIL} - Upland Soil Concentration
C_{WATER} - Surface Water Concentration
COEC - chemical of ecological concern
EPC - exposure point concentration
ERBCL - ecological risk-based cleanup level
HI - hazard index
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
mg/kg - milligrams per kilogram
mg/kg-day - milligrams per kilogram per day
NA - not applicable
NOAEL - no observed adverse effects level
TRV - toxicity reference value

Exposure Parameters

Body Weight:	0.0195	kg
Food Ingestion Rate (FIR):	0.0038	kg (dry wt)/day
FIR_Plants (61.5%):	0.0023	kg (dry wt)/day
FIR_Inverts (38.5%):	0.0015	kg (dry wt)/day
FIR_Soil (2%):	0.0001	kg (dry wt)/day
Water Ingestion Rate:	0	L/day
Exposure Duration (ED):	1	unitless
Site Utilization Factor (SUF):	1	unitless
Home range:	0.27	acres
Exposure area:	412	acres

[a] The abiotic media exposure point concentrations used in the Tier II Ecological Risk Assessment are equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration measured in samples collected from the Ballard Mine.

[b] The soil-to-plant bioaccumulation factor was derived from sources listed in Table 4-15 and 4-16 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop. The site-specific soil-to-plant bioaccumulation factor, where available, is equal to the measured plant concentration divided by the measured soil concentration.

[c] The plant (C_{PLANT}) and terrestrial invertebrate (C_{INVERT}) concentrations were calculated from upland soil concentration and the soil-to-biota bioconcentration factors ($BCF_{S\text{-}P}$ and $BCF_{S\text{-}I}$).

[d] The measured plant concentration is equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration detected in plant tissue collected from Ballard Mine.

[e] The ingestion dose for the accounts for exposure to soil based upon terrestrial foraging habits as presented in Table 4-17 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop, and uses measured plant tissue concentrations, where available, in preference to plant tissue concentrations modeled from upland soil.

Table A-16
Ecological Risk-Based Cleanup Level Calculations for Upland Soil - American Robin

COEC	EPC [a] $C_{UP\ SOIL}$ (mg/kg)	EPC [a] C_{WATER} (mg/L)	ERBCL $C_{UP\ SOIL}$ (mg/kg)	BAF_{S-P} [b]	BAF_{S-P} [b] (site-specific)	EPC C_{PLANT} [c] (mg/kg)	Measured Plant Concentration [d] (mg/kg)	BAF_{S-I} [b]	EPC C_{INVERT} [c] (mg/kg)	Ingestion Dose [e] (mg/kg-day)	TRV NOAEL (mg/kg-day)	Ecological Ha ard High
Antimony	4.89	NA	--	Regression	na	--	NA	1	--	NA	--	--
Cadmium	37.6	0.00440	3.00	Regression	0.0413	0.124	1.55	Regression	19.8	1.5E+00	1.5E+00	1.0
Chromium, total	327	NA	74.3	0.041	0.0074	0.550	2.42	0.306	22.7	2.7E+00	2.7E+00	1.0
Copper	87.2	0.380	74.5	Regression	0.0689	5.13	6.01	0.515	38.4	4.1E+00	4.1E+00	1.0
Molybdenum	20.0	NA	25.3	0.25	0.9165	23.2	18.3	1	25.3	3.5E+00	3.5E+00	1.0
Nickel	205	NA	77.5	Regression	0.0252	1.95	5.18	1	77.5	6.7E+00	6.7E+00	1.0
Selenium	53.5	2.84	2.70	Regression	0.7415	2.00	39.7	Regression	1.92	2.9E-01	2.9E-01	1.0
Thallium	1.20	NA	3.78	0.0040	0.1116	0.422	0.134	1	3.78	3.5E-01	3.5E-01	1.0
Vanadium	239	0.0430	20.6	0.00485	0.0039	0.0797	0.925	0.042	0.865	3.4E-01	3.4E-01	1.0
Zinc	835	NA	729	Regression	0.0713	52.01	59.6	Regression	743	6.6E+01	6.6E+01	1.0

Notes:

-- not available
BAF_{S-I} - bioaccumulation factor from soil to invertebrates
BAF_{S-P} - bioaccumulation factor from soil to plants
C_{UP_SOIL} - Upland Soil Concentration
C_{WATER} - Surface Water Concentration
COEC - chemical of ecological concern
EPC - exposure point concentration
ERBCL - ecological risk-based cleanup level
HI - hazard index
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
mg/kg - milligrams per kilogram
mg/kg-day - milligrams per kilogram per day
NA - not applicable
NOAEL - no observed adverse effects level
TRV - toxicity reference value

Exposure Parameters

Body Weight:	0.08195	kg
Food Ingestion Rate (FIR):	0.0106	kg (dry wt)/day
FIR_Plants (44.7%):	0.0047	kg (dry wt)/day
FIR_Inverts (55.3%):	0.0059	kg (dry wt)/day
FIR_Soil (10.4%):	0.0011	kg (dry wt)/day
Water Ingestion Rate:	0	L/day
Exposure Duration (ED):	1	unitless
Site Utilization Factor (SUF):	1	unitless
Home range:	0.72	acres
Exposure area:	412	acres

[a] The abiotic media exposure point concentrations used in the Tier II Ecological Risk Assessment are equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration measured in samples collected from the Ballard Mine.

[b] The soil-to-plant bioaccumulation factor was derived from sources listed in Table 4-15 and 4-16 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop. The site-specific soil-to-plant bioaccumulation factor, where available, is equal to the measured plant concentration divided by the measured soil concentration.

[c] The plant (C_{PLANT}) and terrestrial invertebrate (C_{INVERT}) concentrations were calculated from upland soil concentration and the soil-to-biota bioconcentration factors (BCF_{S-P} and BCF_{S-I}).

[d] The measured plant concentration is equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration detected in plant tissue collected from Ballard Mine.

[e] The ingestion dose for the American robin accounts for exposure to soil based upon terrestrial foraging habits as presented in Table 4-17 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop, and uses measured plant tissue concentrations, where available, in preference to plant tissue concentrations modeled from upland soil.

Table A-17
Ecological Risk-Based Cleanup Level Calculations for Upland Soil - Coyote

COEC	EPC [a] $C_{UP\ SOIL}$ (mg/kg)	EPC [a] C_{WATER} (mg/L)	ERBCL $C_{UP\ SOIL}$ (mg/kg)	BAF_{S-P} [b]	BAF_{S-P} [b] (site-specific)	EPC C_{PLANT} [c] (mg/kg)	Measured Plant Concentration [d] (mg/kg)	BAF_{S-I} [b]	EPC C_{INVERT} [c] (mg/kg)	BAF_{S-V} [b]	EPC $C_{VERTEBRATE}$ [c] (mg/kg)	Ingestion Dose [d] (mg/kg-day)	TRV NOAEL (mg/kg-day)	Ecological Ha ard High
Antimony	4.89	NA	34.2	Regression	na	0.175	na	1	34.2	0.05	1.71	5.9E-02	5.9E-02	1.0
Cadmium	37.6	0.00440	503	Regression	0.0413	20.8	1.55	Regression	1,164	Regression	5.37	7.7E-01	7.7E-01	1.0
Chromium, total	327	NA	2,114	0.041	0.0074	15.7	2.42	0.306	647	Regression	64.0	2.4E+00	2.4E+00	1.0
Copper	87.2	0.380	7,198	Regression	0.0689	496	6.01	0.515	3,707	Regression	27.8	5.6E+00	5.6E+00	1.0
Molybdenum	20.0	NA	14.1	0.25	0.9165	12.9	18.3	1	14.1	1	14.1	2.6E-01	2.6E-01	1.0
Nickel	205	NA	1,489	Regression	0.0252	37.5	5.18	1	1,489	Regression	23.5	1.7E+00	1.7E+00	1.0
Selenium	53.5	2.84	92.8	Regression	0.7415	68.8	39.7	Regression	25.7	Regression	3.63	1.4E-01	1.4E-01	1.0
Thallium	1.20	NA	1.30	0.0040	0.1116	0.15	0.134	1	1.30	0.1124	0.147	3.7E-03	3.7E-03	1.0
Vanadium	239	0.0430	5,696	0.00485	0.0039	22.0	0.925	0.042	239	0.0123	70.1	4.2E+00	4.2E+00	1.0
Zinc	835	NA	134,182	Regression	0.0713	9,572	59.6	Regression	4,112	Regression	181	7.5E+01	7.5E+01	1.0

Notes:

BAF_{S-P} - bioaccumulation factor from soil to plants
BAF_{S-I} - bioaccumulation factor from soil to invertebrates
BAF_{S-V} - bioaccumulation factor from soil to terrestrial vertebrates
C_{UP_SOIL} - Upland Soil Concentration
C_{WATER} - Surface Water Concentration
COEC - chemical of ecological concern
EPC - exposure point concentration
ERBCL - ecological risk-based cleanup level
HI - hazard index
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
mg/kg - milligrams per kilogram
mg/kg-day - milligrams per kilogram per day
NA - not applicable
NOAEL - no observed adverse effects level
TRV - toxicity reference value

Exposure Parameters

Parameter	Value	Unit
Body Weight:	13.6	kg
Food Ingestion Rate (FIR):	4.2861	kg (dry wt)/day
FIR_Plants (2%):	0.0857	kg (dry wt)/day
FIR_Inverts (2%):	0.0857	kg (dry wt)/day
FIR_Terrestrial Vertebrates (96%):	4.1147	kg (dry wt)/day
FIR_Soil (2.8%):	0.1200	kg (dry wt)/day
Water Ingestion Rate:	0	L/day
Exposure Duration (ED):	1	unitless
Site Utilization Factor (SUF):	0.0569	unitless
Home range:	7,240	acres
Exposure area:	412	acres

[a] The abiotic media exposure point concentrations used in the Tier II Ecological Risk Assessment are equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration measured in samples collected from the Ballard Mine. The measured plant concentration is equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration detected in plant tissue collected from Ballard Mine.

[b] The soil-to-plant bioaccumulation factor was derived from sources listed in Table 4-15 and 4-16 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop. The site-specific soil-to-plant bioaccumulation factor, where available, is equal to the measured plant concentration divided by the measured soil concentration.

[c] The plant (C_{PLANT}), terrestrial invertebrate (C_{INVERT}), and terrestrial vertebrate ($C_{VERTEBRATE}$) concentrations were calculated from the soil concentration and the soil-to-biota bioconcentration factors.

[d] The measured plant concentration is equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration detected in plant tissue collected from Ballard Mine.

[e] The ingestion dose for the accounts for exposure to soil based upon terrestrial foraging habits as presented in Appendix Table 4-17 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop, and uses measured plant tissue concentrations, where available, in preference to plant tissue concentrations modeled from upland soil.

Table A-18
Ecological Risk-Based Cleanup Level Calculations for Upland Soil - Northern Harrier

COEC	EPC [a] C_{UP_SOIL} (mg/kg)	EPC [a] C_{WATER} (mg/L)	ERBCL C_{UP_SOIL} (mg/kg)	BAF_{S-I} [b]	EPC C_{INVERT} [c] (mg/kg)	BAF_{S-V} [b]	EPC $C_{VERTEBRATES}$ [c] (mg/kg)	Ingestion Dose [d] (mg/kg-day)	TRV NOAEL (mg/kg-day)	Ecological Ha ard High
Antimony	4.89	NA	--	1	--	0.05	--	--	--	--
Cadmium	37.6	0.00440	290	Regression	750	Regression	4.14	1.5E+00	1.5E+00	1.0
Chromium, total	327	NA	728	0.306	223	Regression	29.3	2.7E+00	2.7E+00	1.0
Copper	87.2	0.380	2,052	0.515	1,057	Regression	23.2	4.1E+00	4.1E+00	1.0
Molybdenum	20.0	NA	50.0	1	50.0	1	50.0	3.5E+00	3.5E+00	1.0
Nickel	205	NA	2,489	1	2,489	Regression	29.8	6.7E+00	6.7E+00	1.0
Selenium	53.5	2.84	72.1	Regression	21.4	Regression	3.30	2.9E-01	2.9E-01	1.0
Thallium	1.20	NA	36.3	1	36.3	0.1124	4.08	3.5E-01	3.5E-01	1.0
Vanadium	239	0.0430	249	0.042	10.4	0.0123	3.06	3.4E-01	3.4E-01	1.0
Zinc	835	NA	100,200	Regression	3,736	Regression	177	6.6E+01	6.6E+01	1.0

Notes:
-- not available
BAF_{S-I} - bioaccumulation factor from soil to terrestrial invertebrates
BAF_{S-V} - bioaccumulation factor from soil to terrestrial vertebrates
C_{UP_SOIL} - Upland Soil Concentration
C_{WATER} - Surface Water Concentration
COEC - chemical of ecological concern
EPC - exposure point concentration
ERBSL - ecological risk-based cleanup level
HI - hazard index
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
mg/kg - milligrams per kilogram
mg/kg-day - milligrams per kilogram per day
NA - not applicable
NOAEL - no observed adverse effects level
TRV - toxicity reference value

Exposure Parameters

Parameter	Value
Body Weight:	0.449
Food Ingestion Rate (FIR):	0.049
FIR_Terrestrial Inverts (2%):	0.0010
FIR_Terrestrial Vertebrates (98%):	0.0477
FIR_Upland Soil (0.7%):	0.00034
Water Ingestion Rate:	0
Exposure Duration (ED):	1
Site Utilization Factor (SUF):	0.642
Home range:	642
Exposure area:	412

[a] The abiotic media exposure point concentrations used in the Tier II Ecological Risk Assessment are equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration measured in samples collected from the Ballard Mine.
[b] The abiotic media-to-biota bioconcentration factors were derived from sources listed in Table 4-15 and 4-16 of the Baseline Risk Assessment for Ballard Mine and Ballard Sh
[c] The terrestrial invertebrate (C_{INVERT}) and terrestrial vertebrate ($C_{VERTIBRATE}$) concentrations were calculated from the soil concentration and the soil-to-biota bioconcentration
[d] The ingestion dose for the northern harrier accounts for exposure to soil based upon terrestrial foraging habits as presented in Table 4-17 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop.

Table A-19
Ecological Risk-Based Cleanup Level Calculations for Riparian Soil - Raccoon

Constituent	$C_{RIP\ SOIL}$ (mg/kg)	C_{WATER} (mg/L)	$C_{SEDIMENT}$ (mg/kg)	ERBCL $C_{RIP\ SOIL}$ (mg/kg)	$BAF_{S\text{-}P}$ [b]	$BAF_{S\text{-}P}$ [b] (site-specific)	EPC C_{PLANT} [c] (mg/kg)	Measured Plant Concentration [d] (mg/kg)	$BAF_{S\text{-}I}$ [b]	EPC C_{INVERT} [c] (mg/kg)	$BAF_{S\text{-}V}$ [b]	EPC $C_{VERTEBRATES}$ [c] (mg/kg)	$BAF_{Sed\text{-}I}$ [b]	$BAF_{W\text{-}I}$ [b]	EPC $C_{AQ\ INVERT}$ [c] (mg/kg)	Ingestion Dose [e] (mg/kg-day)	TRV NOAEL (mg/kg-day)	Ecological Ha ard High
Cadmium	25.4	0.00440	42.1	181	Regression	0.0756	13.7	1.92	Regression	516	Regression	3.31	Regression	NA	14.6	7.7E-01	7.7E-01	1.0
Chromium, total	503	NA	358	2,461	0.041	NA	101	NA	0.306	753	Regression	71.5	Regression	NA	13.8	2.4E+00	2.4E+00	1.0
Copper	71.1	0.380	51.1	4,410	Regression	0.0555	245	3.95	0.515	2,271	Regression	25.9	Regression	NA	36.6	5.6E+00	5.6E+00	1.0
Molybdenum	16.4	NA	12.8	53.4	0.25	0.8735	46.6	14.4	1	53.4	1	53.4	1	NA	12.8	2.6E-01	2.6E-01	1.0
Nickel	281	NA	171	960	Regression	NA	18.4	NA	1	960	Regression	19.1	Regression	NA	3.39	1.7E+00	1.7E+00	1.0
Selenium	89.5	2.84	208	105	Regression	0.1799	18.9	16.1	Regression	28.2	Regression	3.81	Regression	NA	46.5	1.4E-01	1.4E-01	1.0
Thallium	0.376	NA	1.30	2.09	0.0040	NA	0.00837	NA	1	2.09	0.1124	0.235	1	NA	1.30	3.7E-03	3.7E-03	1.0
Vanadium	233	0.0430	321	7,916	0.00485	NA	38.4	NA	0.042	332	0.0123	97.4	0.042	NA	13.5	4.2E+00	4.2E+00	1.0

Notes:
$BAF_{S\text{-}I}$ - bioaccumulation factor from soil to invertebrates
$BAF_{S\text{-}P}$ - bioaccumulation factor from soil to plants
$BAF_{S\text{-}V}$ - bioaccumulation factor from soil to terrestrial vertebrates
$BAF_{Sed\text{-}I}$ - bioaccumulation factor from sediment to aquatic invertebrates
$BAF_{W\text{-}I}$ - bioaccumulation factor from water to aquatic invertebrates
C_{RIP_SOIL} - Riparian Soil Concentration
$C_{SEDIMENT}$ - Sediment Concentration
C_{WATER} - Surface Water Concentration
COEC - chemical of ecological concern
EPC - exposure point concentration
ERBCL - ecological risk-based cleanup level
HI - hazard index
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
mg/kg - milligrams per kilogram
mg/kg-day - milligrams per kilogram per day
NA - not applicable
NOAEL - no observed adverse effects level
TRV - toxicity reference value

Exposure Parameters

Body Weight:	5.8
Food Ingestion Rate (FIR):	0.154
FIR_Terrestrial Plants (64%):	0.0985
FIR_Terrestrial Inverts (19%):	0.0400
FIR_Terrestrial Vertebrates (9%):	0.0154
FIR_Upland Soil (0%):	0
FIR_Aquatic Plants (0%):	0
FIR_Aquatic Inverts (7%):	0
FIR_Fish (1%):	0
FIR_Riparian Soil (9.4%):	0.0145
Water Ingestion Rate:	0
Exposure Duration (ED):	1
Site Utilization Factor (SUF):	0.181
Home range:	2,272
Exposure area:	412

[a] The abiotic media exposure point concentrations used in the Tier II Ecological Risk Assessment are equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration measured in samples collected from the Ballard Mine.

[b] The soil-to-plant bioaccumulation factor was derived from sources listed in Table 4-15 and 4-16 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop. The site-specific soil-to-plant bioaccumulation factor, where available, is equal to the measured plant concentration divided by the measured soil concentration.

[c] The terrestrial plant (C_{PLANT}), terrestrial invertebrate (C_{INVERT}), aquatic invertebrate ($C_{AQ\ INVERT}$), and terrestrial vertebrate ($C_{VERTIBRATE}$) concentrations were calculated from the soil or sediment concentration and the soil or sediment-to-biota bioconcentration factors.

[d] The measured plant concentration is equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration detected in plant tissue collected from Ballard Mine.

[e] The ingestion dose for the accounts for exposure to soil based upon terrestrial foraging habits as presented in Table 4-17 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop, and uses measured plant tissue concentrations, where available, in preference to plant tissue concentrations modeled from riparian soil. Because fish are not present in streams at the Ballard Mine, ingestion of fish was replaced by ingestion of aquatic invertebrates.

Table A-20
Ecological Risk-Based Cleanup Level Calculations for Riparian Soil - Mink

	EPC [a]			ERBCL		EPC			EPC	Ingestion	TRV	Ecological
	$C_{RIP\ SOIL}$	C_{WATER}	$C_{SEDIMENT}$	$C_{RIP\ SOIL}$	BAF_{S-V} [b]	$C_{VERTEBRATES}$ [c]	BAF_{Sed-I} [b]	BAF_{W-I} [b]	$C_{AQ\ INVERT}$ [c]	Dose [d]	NOAEL	Ha ard
COEC	(mg/kg)	(mg/L)	(mg/kg)	(mg/kg)		(mg/kg)			(mg/kg)	(mg/kg-day)	(mg/kg-day)	High
Cadmium	25.4	0.00440	42.1	8.66	Regression	0.789	Regression	NA	14.6	7.7E-01	7.7E-01	1.0
Chromium, total	503	NA	358	26.1	Regression	2.54	Regression	NA	13.8	2.4E+00	2.4E+00	1.0
Copper	71.1	0.380	51.1	9.90	Regression	10.7	Regression	NA	36.6	5.6E+00	5.6E+00	1.0
Molybdenum	16.4	NA	12.8	0.495	1	0.495	1	NA	12.8	2.6E-01	2.6E-01	1.0
Nickel	281	NA	171	11.6	Regression	2.45	Regression	NA	3.39	1.7E+00	1.7E+00	1.0
Selenium	89.5	2.84	208	0.110	Regression	0.287	Regression	NA	46.5	1.4E-01	1.4E-01	1.0
Thallium	0.376	NA	1.30	0.0373	0.1124	0.00420	1	NA	1.30	3.7E-03	3.7E-03	1.0
Vanadium	233	0.0430	321	81.5	0.0123	1.00	0.042	NA	13.5	4.2E+00	4.2E+00	1.0

Notes:

BAF_{S-V} - bioaccumulation factor from soil to terrestrial vertebrates
BAF_{Sed-I} - bioaccumulation factor from sediment to aquatic invertebrates
BAF_{W-I} - bioaccumulation factor from water to aquatic invertebrates
C_{RIP_SOIL} - Riparian Soil Concentration
$C_{SEDIMENT}$ - Sediment Concentration
C_{WATER} - Surface Water Concentration
COEC - chemical of ecological concern
EPC - exposure point concentration
ERBCL - ecological risk-based cleanup level
HI - hazard index
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
mg/kg - milligrams per kilogram
mg/kg-day - milligrams per kilogram per day
NA - not applicable
NOAEL - no observed adverse effects level
TRV - toxicity reference value

Exposure Parameters

Body Weight:	1.075	kg
Food Ingestion Rate (FIR):	0.516	kg (dry wt)/day
FIR_Terrestrial Vertebrates (63%):	0.516	kg (dry wt)/day
FIR_Upland Soil (0%):	0	kg (dry wt)/day
FIR_Aquatic Inverts (6%):	0	kg (dry wt)/day
FIR_Fish (31%):	0	kg (dry wt)/day
FIR_Riparian Soil (9.4%):	0.0485	kg (dry wt)/day
Water Ingestion Rate:	0	L/day
Exposure Duration (ED):	1	unitless
Site Utilization Factor (SUF):	1	unitless
Home range:	50	acres
Exposure area:	412	acres

[a] The abiotic media exposure point concentrations used in the Tier II Ecological Risk Assessment are equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration measured in samples collected from the Ballard Mine.

[b] The abiotic media-to-biota bioconcentration factors were derived from sources listed in Table 4-15 and 4-16 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop.

[c] The aquatic invertebrate ($C_{AQ\ INVERT}$) and terrestrial vertebrate ($C_{VERTIBRATE}$) concentrations were calculated from the soil or sediment concentration and the soil or sediment-to-biota

[d] The ingestion dose for the accounts for exposure to soil based upon terrestrial foraging habits as presented in Table 4-17 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop. Because fish are not present in streams at the Ballard Mine, ingestion of fish was replaced by ingestion of aquatic invertebrates.

Table A-21
Ecological Risk-Based Cleanup Level Calculations for Riparian Soil - Great Blue Heron

	EPC [a]			ERBCL		EPC		EPC			EPC	Ingestion	TRV	Ecological
	$C_{RIP\ SOIL}$	C_{WATER}	$C_{SEDIMENT}$	$C_{RIP\ SOIL}$	$BAF_{S\text{-}I}$ [b]	C_{INVERT} [c]	$BAF_{S\text{-}V}$ [b]	$C_{VERTEBRATES}$ [c]	$BAF_{Sed\text{-}I}$ [b]	$BAF_{W\text{-}I}$ [b]	$C_{AQ\ INVERT}$ [c]	Dose [d]	NOAEL	Ha ard
Constituent	(mg/kg)	(mg/L)	(mg/kg)	(mg/kg)		(mg/kg)		(mg/kg)			(mg/kg)	(mg/kg-day)	(mg/kg-day)	High
Cadmium	25.4	0.00440	42.1	8.74	Regression	46.4	Regression	0.792	Regression	NA	14.6	1.5E+00	1.5E+00	1.0
Chromium, total	503	NA	358	238	0.306	72.7	Regression	12.9	Regression	NA	13.8	2.7E+00	2.7E+00	1.0
Copper	71.1	0.380	51.1	220	0.515	113	Regression	16.8	Regression	NA	36.6	4.1E+00	4.1E+00	1.0
Molybdenum	16.4	NA	12.8	56.3	1	56.3	1	56.3	1	NA	12.8	3.5E+00	3.5E+00	1.0
Nickel	281	NA	171	206	1	206	Regression	9.36	Regression	NA	3.39	6.7E+00	6.7E+00	1.0
Selenium	89.5	2.84	208	17.0	Regression	7.41	Regression	1.92	Regression	NA	46.5	2.9E-01	2.9E-01	1.0
Thallium	0.376	NA	1.30	10.0	1	10.0	0.1124	1.12	1	NA	1.30	3.5E-01	3.5E-01	1.0
Vanadium	233	0.0430	321	204	0.042	8.56	0.0123	2.51	0.042	NA	13.5	3.4E-01	3.4E-01	1.0

Notes:

$BAF_{S\text{-}I}$ - bioaccumulation factor from soil to terrestrial invertebrates
$BAF_{S\text{-}V}$ - bioaccumulation factor from soil to terrestrial vertebrates (birds and mammals)
C_{RIP_SOIL} - Riparian Soil Concentration
$C_{SEDIMENT}$ - Sediment Concentration
C_{WATER} - Surface Water Concentration
COEC - chemical of ecological concern
EPC - exposure point concentration
ERBCL - ecological risk-based cleanup level
HI - hazard index
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
mg/kg - milligrams per kilogram
mg/kg-day - milligrams per kilogram per day
NA - not applicable
NOAEL - no observed adverse effects level
TRV - toxicity reference value

Exposure Parameters

Body Weight:	2.336	kg
Food Ingestion Rate (FIR):	0.145	kg (dry wt)/day
FIR_Terrestrial Inverts (12.5%):	0.0726	kg (dry wt)/day
FIR_Terrestrial Vertebrates (12.5%):	0.0726	kg (dry wt)/day
FIR_Upland Soil (0%):	0	kg (dry wt)/day
FIR_Fish (75%):	0	kg (dry wt)/day
FIR_Riparian Soil (0%):	0	kg (dry wt)/day
FIR_Sediment (0.7%):	0	kg (dry wt)/day
Water Ingestion Rate:	0	L/day
Exposure Duration (ED):	1	unitless
Site Utilization Factor (SUF):	1	unitless
Home range:	11	acres
Exposure area:	412	acres

[a] The abiotic media exposure point concentrations used in the Tier II Ecological Risk Assessment are equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration measured in samples collected from the Ballard Mine.

[b] The abiotic media-to-biota bioconcentration factors were derived from sources listed in Table 4-15 and 4-16 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop.

[c] The terrestrial invertebrate (C_{INVERT}), terrestrial vertebrate ($C_{VERTIBRATE}$), and aquatic invertebrate ($C_{AQ\ INVERT}$) concentrations were calculated from the soil or sediment concentration and the soil or sediment-to-biota bioconcentration factors.

[d] The ingestion dose for the accounts for exposure to soil based upon terrestrial foraging habits as presented in Table 4-17 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop. Because fish are not present in streams at the Ballard Mine, ingestion of fish was replaced by ingestion of aquatic invertebrates.

Table A-22
Ecological Risk-Based Cleanup Level Calculations for Sediment - Raccoon

	EPC [a]			ERBCL		EPC	Measured Plant		EPC		EPC		EPC			EPC	Ingestion	TRV	Ecological
	$C_{RIP\ SOIL}$	C_{WATER}	$C_{SEDIMENT}$	$C_{SEDIMENT}$	$BAF_{S\text{-}P}$ [b]	C_{PLANT} [c]	Concentration [d]	$BAF_{S\text{-}I}$ [b]	C_{INVERT} [c]	$BAF_{S\text{-}V}$ [b]	$C_{VERTEBRATES}$ [c]	$BAF_{Sed\text{-}P}$ [b]	$C_{AQ\ PLANT}$ [c]	$BAF_{Sed\text{-}I}$ [b]	$BAF_{W\text{-}I}$ [b]	$C_{AQ\ INVERT}$ [c]	Dose [e]	NOAEL	Ha ard
COEC	**(mg/kg)**	**(mg/L)**	**(mg/kg)**	**(mg/kg)**		**(mg/kg)**	**(mg/kg)**		**(mg/kg)**		**(mg/kg)**		**(mg/kg)**			**(mg/kg)**	**(mg/kg-day)**	**(mg/kg-day)**	**High**
Antimony	4.62	NA	6.05	25.8	Regression	0.166	NA	1	4.62	0.05	0.231	Regression	0.833	1	NA	25.8	5.9E-02	5.9E-02	1.0
Cadmium	25.4	0.00440	42.1	1,013	Regression	3.63	1.92	Regression	108	Regression	1.31	Regression	27.2	Regression	NA	132	7.7E-01	7.7E-01	1.0
Copper	71.1	0.380	51.1	11,233	Regression	10.5	3.95	0.515	36.6	Regression	14.3	Regression	76.9	Regression	NA	164	5.6E+00	5.6E+00	1.0
Molybdenum	16.4	NA	12.8	88.0	0.25	4.11	14.4	1	16.4	1	16.4	0.25	22.0	1	NA	88.0	2.6E-01	2.6E-01	1.0
Selenium	89.5	2.84	208	42.6	Regression	72.6	16.1	Regression	25.0	Regression	3.58	Regression	32.0	Regression	NA	14.5	1.4E-01	1.4E-01	1.0
Thallium	0.376	NA	1.30	1.68	0.0040	0.00150	NA	1	0.376	0.1124	0.0423	0.004	0.00674	1	NA	1.68	3.7E-03	3.7E-03	1.0
Vanadium	233	0.0430	321	7,707	0.00485	1.13	NA	0.042	9.78	0.0123	2.86	0.00485	37.4	0.042	NA	324	4.2E+00	4.2E+00	1.0

Notes:

$BAF_{S\text{-}I}$ - bioaccumulation factor from soil to invertebrates
$BAF_{S\text{-}P}$ - bioaccumulation factor from soil to plants
$BAF_{S\text{-}V}$ - bioaccumulation factor from soil to terrestrial vertebrates
$BAF_{Sed\text{-}I}$ - bioaccumulation factor from sediment to aquatic invertebrates
$BAF_{W\text{-}I}$ - bioaccumulation factor from water to aquatic invertebrates
C_{RIP_SOIL} - Riparian Soil Concentration
$C_{SEDIMENT}$ - Sediment Concentration
C_{WATER} - Surface Water Concentration
COEC - chemical of ecological concern
EPC - exposure point concentration
ERBCL - ecological risk-based cleanup level
HI - hazard index
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
mg/kg - milligrams per kilogram
mg/kg-day - milligrams per kilogram per day
NA - not applicable
NOAEL - no observed adverse effects level
TRV - toxicity reference value

Exposure Parameters	
Body Weight:	5.8
Food Ingestion Rate (FIR):	0.154
FIR_Terrestrial Plants (64%):	0
FIR_Terrestrial Inverts (19%):	0
FIR_Terrestrial Vertebrates (9%):	0
FIR_Upland Soil (0%):	0
FIR_Aquatic Plants (0%):	0.0985
FIR_Aquatic Inverts (7%):	0.0400
FIR_Fish (1%):	0.0154
FIR_Riparian Soil (9.4%):	0.0145
Water Ingestion Rate:	0
Exposure Duration (ED):	1
Site Utilization Factor (SUF):	0.181
Home range:	2,272
Exposure area:	412

[a] The abiotic media exposure point concentrations used in the Tier II Ecological Risk Assessment are equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration measured in samples collected from the Ballard Mine.

[b] The abiotic media-to-biota bioconcentration factors were derived from sources listed in Table 4-15 and 4-16 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop.

[c] The terrestrial plant (C_{PLANT}), terrestrial invertebrate (C_{INVERT}), aquatic invertebrate ($C_{AQ\ INVERT}$), and terrestrial vertebrate ($C_{VERTIBRATE}$) concentrations were calculated from the soil or sediment concentration and the soil or sediment-to-biota bioconcentration factors.

[d] The measured plant concentration is equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration detected in plant tissue collected from Ballard Mine.

[e] The ingestion dose for the accounts for exposure to soil based upon terrestrial foraging habits as presented in Table 4-17 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop, and uses measured plant tissue concentrations, where available, in preference to plant tissue concentrations modeled from riparian soil. Because fish are not present in streams at the Ballard Mine, ingestion of fish was replaced by ingestion of aquatic invertebrates.

Table A-23
Ecological Risk-Based Cleanup Level Calculations for Sediment - Mink

	EPC [a]			ERBCL		EPC			EPC	Ingestion	TRV	Ecological
	$C_{RIP\ SOIL}$	C_{WATER}	$C_{SEDIMENT}$	$C_{SEDIMENT}$	$BAF_{S\text{-}V}$ [b]	$C_{VERTEBRATES}$ [c]	$BAF_{Sed\text{-}I}$ [b]	$BAF_{W\text{-}I}$ [b]	$C_{AQ\ INVERT}$ [c]	Dose [d]	NOAEL	Ha ard
COEC	**(mg/kg)**	**(mg/L)**	**(mg/kg)**	**(mg/kg)**		**(mg/kg)**			**(mg/kg)**	**(mg/kg-day)**	**(mg/kg-day)**	**High**
Antimony	4.62	NA	6.05	0.123	0.05	0.231	1	NA	0.123	5.9E-02	5.9E-02	1.0
Cadmium	25.4	0.00440	42.1	1.73	Regression	1.31	Regression	NA	1.60	7.7E-01	7.7E-01	1.0
Copper	71.1	0.380	51.1	0.831	Regression	14.3	Regression	NA	11.7	5.6E+00	5.6E+00	1.0
Molybdenum	16.4	NA	12.8	0.541	1	16.4	1	NA	0.541	2.6E-01	2.6E-01	1.0
Selenium	89.5	2.84	208	0.212	Regression	3.58	Regression	NA	0.298	1.4E-01	1.4E-01	1.0
Thallium	0.376	NA	1.30	0.00770	0.1124	0.0423	1	NA	0.00770	3.7E-03	3.7E-03	1.0
Vanadium	233	0.0430	321	206	0.0123	2.86	0.042	NA	8.66	4.2E+00	4.2E+00	1.0

Notes:

$BAF_{S\text{-}V}$ - bioaccumulation factor from soil to terrestrial vertebrates
$BAF_{Sed\text{-}I}$ - bioaccumulation factor from sediment to aquatic invertebrates
$BAF_{W\text{-}I}$ - bioaccumulation factor from water to aquatic invertebrates
C_{RIP_SOIL} - Riparian Soil Concentration
$C_{SEDIMENT}$ - Sediment Concentration
C_{WATER} - Surface Water Concentration
COEC - chemical of ecological concern
EPC - exposure point concentration
ERBCL - ecological risk-based cleanup level
HI - hazard index
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
mg/kg - milligrams per kilogram
mg/kg-day - milligrams per kilogram per day
NA - not applicable
NOAEL - no observed adverse effects level
TRV - toxicity reference value

Exposure Parameters		
Body Weight:	1.075	kg
Food Ingestion Rate (FIR):	0.516	kg (dry wt)/day
FIR_Terrestrial Vertebrates (63%):	0	kg (dry wt)/day
FIR_Upland Soil (0%):	0	kg (dry wt)/day
FIR_Aquatic Inverts (6%):	0.0826	kg (dry wt)/day
FIR_Fish (31%):	0.434	kg (dry wt)/day
FIR_Riparian Soil (9.4%):	0	kg (dry wt)/day
Water Ingestion Rate:	0	L/day
Exposure Duration (ED):	1	unitless
Site Utilization Factor (SUF):	1	unitless
Home range:	50	acres
Exposure area:	412	acres

[a] The abiotic media exposure point concentrations used in the Tier II Ecological Risk Assessment are equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration measured in samples collected from the Ballard Mine.

[b] The abiotic media-to-biota bioconcentration factors were derived from sources listed in Table 4-15 and 4-16 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop.

[c] The aquatic invertebrate ($C_{AQ\ INVERT}$) and terrestrial vertebrate ($C_{VERTIBRATE}$) concentrations were calculated from the soil or sediment concentration and the soil or sediment-to-biota bioaccumulation factors.

[d] The ingestion dose for the mink accounts for exposure to soil based upon terrestrial foraging habits as presented in Table 4-17 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop. Because fish are not present in streams at the Ballard Mine, ingestion of fish was replaced by ingestion of aquatic invertebrates.

Table A-24
Ecological Risk-Based Cleanup Level Calculations for Sediment - Great Blue Heron

	EPC [a]			ERBCL	BAF_{S-I} [b]	EPC	BAF_{S-V} [b]	EPC	BAF_{Sed-I} [b]	BAF_{W-I} [b]	EPC	Ingestion	TRV	Ecological
	$C_{RIP\ SOIL}$	C_{WATER}	$C_{SEDIMENT}$	$C_{SEDIMENT}$		C_{INVERT} [c]		$C_{VERTEBRATES}$ [c]			$C_{AQ\ INVERT}$ [c]	Dose [d]	NOAEL	Ha ard
COEC	(mg/kg)	(mg/L)	(mg/kg)	(mg/kg)		(mg/kg)		(mg/kg)			(mg/kg)	(mg/kg-day)	(mg/kg-day)	High
Antimony	4.62	NA	6.05	--	1	4.62	0.05	0.231	1	NA	--	--	--	--
Cadmium	25.4	0.00440	42.1	81.5	Regression	108	Regression	1.31	Regression	NA	23.0	1.5E+00	1.5E+00	1.0
Copper	71.1	0.380	51.1	352	0.515	36.6	Regression	14.3	Regression	NA	62.7	4.1E+00	4.1E+00	1.0
Molybdenum	16.4	NA	12.8	55.9	1	16.4	1	16.4	1	NA	55.9	3.5E+00	3.5E+00	1.0
Selenium	89.5	2.84	208	8.89	Regression	25.0	Regression	3.58	Regression	NA	4.60	2.9E-01	2.9E-01	1.0
Thallium	0.376	NA	1.30	5.53	1	0.376	0.1124	0.0423	1	NA	5.53	3.5E-01	3.5E-01	1.0
Vanadium	233	0.0430	321	113	0.042	9.78	0.0123	2.86	0.042	NA	4.74	3.4E-01	3.4E-01	1.0

Notes:

-- not available
BAF_{S-I} - bioaccumulation factor from soil to terrestrial invertebrates
BAF_{S-V} - bioaccumulation factor from soil to terrestrial vertebrates (birds and mammals)
C_{RIP_SOIL} - Riparian Soil Concentration
$C_{SEDIMENT}$ - Sediment Concentration
C_{WATER} - Surface Water Concentration
COEC - chemical of ecological concern
EPC - exposure point concentration
ERBCL - ecological risk-based screening level
HI - hazard index
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
mg/kg - milligrams per kilogram
mg/kg-day - milligrams per kilogram per day
NA - not applicable
NOAEL - no observed adverse effects level
TRV - toxicity reference value

Exposure Parameters

Body Weight:	2.336	kg
Food Ingestion Rate (FIR):	0.145	kg (dry wt)/day
FIR_Terrestrial Inverts (12.5%):	0	kg (dry wt)/day
FIR_Terrestrial Vertebrates (12.5%):	0	kg (dry wt)/day
FIR_Upland Soil (0%):	0	kg (dry wt)/day
FIR_Fish (75%):	0.145	kg (dry wt)/day
FIR_Riparian Soil (0%):	0	kg (dry wt)/day
FIR_Sediment (0.7%):	0.00102	kg (dry wt)/day
Water Ingestion Rate:	0	L/day
Exposure Duration (ED):	1	unitless
Site Utilization Factor (SUF):	1	unitless
Home range:	11	acres
Exposure area:	412	acres

[a] The abiotic media exposure point concentrations used in the Tier II Ecological Risk Assessment are equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration measured in samples collected from the Ballard Mine.

[b] The abiotic media-to-biota bioconcentration factors were derived from sources listed in Table 4-15 and 4-16 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop.

[c] The terrestrial invertebrate (C_{INVERT}), terrestrial vertebrate ($C_{VERTIBRATE}$), and aquatic invertebrate ($C_{AQ\ INVERT}$) concentrations were calculated from the soil or sediment concentration and the soil or sediment-to-biota bioconcentration factors.

[d] The ingestion dose for the accounts for exposure to soil based upon terrestrial foraging habits as presented in Table 4-17 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop. Because fish are not present in streams at the Ballard Mine, ingestion of fish was replaced by ingestion of aquatic invertebrates.

Table A-25
Ecological Risk-Based Cleanup Level Calculations for Sediment - Mallard

	EPC[a]		ERBCL			EPC			EPC	Ingestion	TRV	Ecological
	C_{WATER}	$C_{SEDIMENT}$	$C_{SEDIMENT}$	BAF_{Sed-P} [b]	BAF_{W-P} [b]	$C_{AQ\ PLANT}$ [c]	BAF_{Sed-I} [b]	BAF_{W-I} [b]	$C_{AQ\ INVERT}$ [c]	Dose [d]	NOAEL	Ha ard
Constituent	**(mg/L)**	**(mg/kg)**	**(mg/kg)**			**(mg/kg)**			**(mg/kg)**	**(mg/kg-day)**	**(mg/kg-day)**	**High**
Antimony	NA	6.05	--	Regression	NA	--	1	NA	--	--	--	--
Cadmium	0.00440	42.1	486	Regression	NA	18.2	Regression	NA	79.2	1.5E+00	1.5E+00	1.0
Copper	0.380	51.1	3,595	Regression	NA	49.1	Regression	NA	120	4.1E+00	4.1E+00	1.0
Molybdenum	NA	12.8	226	0.25	NA	56.5	1	NA	226	3.5E+00	3.5E+00	1.0
Selenium	2.84	208	16.8	Regression	NA	11.5	Regression	NA	16.5	2.9E-01	2.9E-01	1.0
Thallium	NA	1.30	24.1	0.004	NA	0.0964	1	NA	24.1	3.5E-01	3.5E-01	1.0
Vanadium	0.0430	321	285	0.00485	NA	1.38	0.042	NA	12.0	3.4E-01	3.4E-01	1.0

Notes:

-- not available
BAF_{Sed-I} - bioaccumulation factor from sediment to aquatic invertebrates
BAF_{Sed-P} - bioaccumulation factor from sediment to aquatic plants
BCF_{W-I} - bioaccumulation factor from water to aquatic invertebrates
BCF_{W-P} - bioaccumulation factor from water to aquatic plants
$C_{SEDIMENT}$ - Sediment Concentration
C_{WATER} - Surface Water Concentration
EPC - exposure point concentration
HI - hazard index
HQ - hazard quotient
LOAEL - lowest observed adverse effects level
mg/kg - milligrams per kilogram
mg/kg-day - milligrams per kilogram per day
NA - not applicable
NOAEL - no observed adverse effects level
TRV - toxicity reference value

Exposure Parameters

Body Weight:	1.178	kg
Food Ingestion Rate (FIR):	0.056	kg (dry wt)/day
FIR_Aquatic Plants (25%):	0.01	kg (dry wt)/day
FIR_Aquatic Inverts (75%):	0.0422	kg (dry wt)/day
FIR_Sediment (3.3%):	0.0019	kg (dry wt)/day
Water Ingestion Rate:	0	L/day
Exposure Duration (ED):	1	unitless
Site Utilization Factor (SUF):	0.384	unitless
Home range:	1,074	acres
Exposure area:	412	acres

[a] The abiotic media exposure point concentrations used in the Tier II Ecological Risk Assessment are equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration measured in samples collected from the Ballard Mine. The measured plant concentration is equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration detected in plant tissue collected from Ballard Mine.

[b] The abiotic media-to-biota bioconcentration factors were derived from sources listed in Table 4-15 and 4-16 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop.

[c] The aquatic plant ($C_{AQ\ PLANT}$) and aquatic invertebrate ($C_{AQ\ INVERT}$) concentrations were calculated from the sediment concentration and the sediment-to-biota bioaccumulation factors.

[d] The ingestion dose for the mallard accounts for exposure to soil based upon terrestrial foraging habits as presented in Table 4-17 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop.

Table A-26
Risk-Based Cleanup Levels for Ecological Receptors

Upland Soil COEC	Long-Tailed Vole	Elk	American Goldfinch	Deer Mouse	American Robin	Coyote	Northern Harrier
Antimony	3.15	6,943	--	0.703	--	34.2	--
Cadmium	38.2	63,265	38.2	1.28	3.00	503	290
Chromium	247	440,862	90.4	86.3	74.3	2,114	728
Copper	195	317,302	88.7	110	74.5	7,198	2,052
Molybdenum	0.895	1,398	13.0	1.37	25.3	14.1	50.0
Nickel	112	189,385	197	20.7	77.5	1,489	2,489
Selenium	0.605	946	1.30	0.864	2.70	92.8	72.1
Thallium	0.0884	142	6.07	0.0400	3.78	1.30	36.26
Vanadium	483	877,540	12.1	552	20.6	5,696	249
Zinc	2,562	NA[a]	1,426	1,028	729	134,182	100,200
Riparian Soil COEC	**Raccoon**	**Mink**	**Great Blue Heron**				
Cadmium	181	8.66	8.74				
Chromium	2,461	26.1	238				
Copper	4,410	9.90	220				
Molybdenum	53.4	0.495	56.3				
Nickel	960	11.6	206				
Selenium	105	0.110	17.0				
Thallium	2.09	0.0373	10.0				
Vanadium	7,916	81.5	204				
Sediment COEC	**Raccoon**	**Mink**	**Great Blue Heron**	**Mallard**			
Antimony	25.8	0.123	--	--			
Cadmium	1,013	1.73	81.5	486			
Copper	11,233	0.831	352	3,595			
Molybdenum	88.0	0.541	55.9	226			
Selenium	42.6	0.212	8.89	16.8			
Thallium	1.68	0.00770	5.53	24.1			
Vanadium	7,707	206	113	285			

Notes:

- Indicates that the metal was not a COEC for that receptor / medium.
All concentrations are in milligrams per kilogram (mg/kg).

COEC - chemical of ecological concern

[a] Concentration exceeds $1x10^{-6}$ milligrams per kilogram.

Table A-27
Livestock Risk-Based Cleanup Level Calculation for Upland Soil - Beef Cattle

LCOC	EPC [a] $C_{UP\ SOIL}$ (mg/kg)	EPC [a] C_{WATER} (mg/L)	LRBCL $C_{UP\ SOIL}$ (mg/kg)	$BAF_{S\text{-}P}$ [b]	$BAF_{S\text{-}P}$ [b] (site-specific)	EPC C_{PLANT} [c] (mg/kg)	Measured Plant Concentration [d] (mg/kg)	Ingestion Dose [e] (mg/kg-day)	TRV NOAEL mg/kg-day	Ecological Ha ard High
Selenium	53.5	2.84	24.8	Regression	0.741	18.4	39.7	1.4E-01	1.4E-01	1.0

Notes:
$BAF_{S\text{-}P}$ - bioaccumulation factor from soil to plants
C_{UP_SOIL} - Upland Soil Concentration
C_{WATER} - Surface Water Concentration
LCOC - chemical of concern
EPC - exposure point concentration
HI - hazard index
HQ - hazard quotient
LRBCL - livestock risk-based cleanup level
LOAEL - lowest observed adverse effects level
mg/kg - milligrams per kilogram
mg/kg-day - milligrams per kilogram per day
mg/L - milligrams per liter
NOAEL - no observed adverse effects level
TRV - toxicity reference value

Exposure Parameters

Body Weight:		510	kg
Food Ingestion Rate (FIR):		11.77	kg (dry wt)/day
	FIR_Plants (100%):	11.77	kg (dry wt)/day
	FIR_Soil (2%):	0.2354	kg (dry wt)/day
Water Ingestion Rate:		0	L/day
Exposure Duration (ED):		0	unitless
Site Utilization Factor (SUF):		1	unitless
	Home range:	--	acres
	Exposure area:	412	acres

[a] The abiotic media exposure point concentrations used in the Tier II Livestock Risk Assessment are equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration measured in samples collected from the Ballard Mine.

[b] The soil-to-plant bioaccumulation factor was derived from sources listed in Table 4-15 and 4-16 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop. The site-specific soil-to-plant bioaccumulation factor, where available, is equal to the measured plant concentration divided by the measured soil concentration.

[c] The plant concentration (C_{PLANT}) was calculated from the upland soil concentration and the soil-to-plant bioconcentration factor ($BCF_{S\text{-}P}$).

[d] The measured plant concentration is equal to the lower of the maximum detected concentration or ProUCL recommended 95%, 97.5% or 99% upper confidence limit on the mean concentration detected in plant tissue collected from Ballard Mine.

[e] The ingestion dose for the accounts for exposure to soil based upon terrestrial foraging habits as presented in Table 4-17 of the Baseline Risk Assessment for Ballard Mine and Ballard Shop, and uses measured plant tissue concentrations, where available, in preference to plant tissue concentrations modeled from upland soil.

Table A-28
Risk-Based Cleanup Levels for Livestock

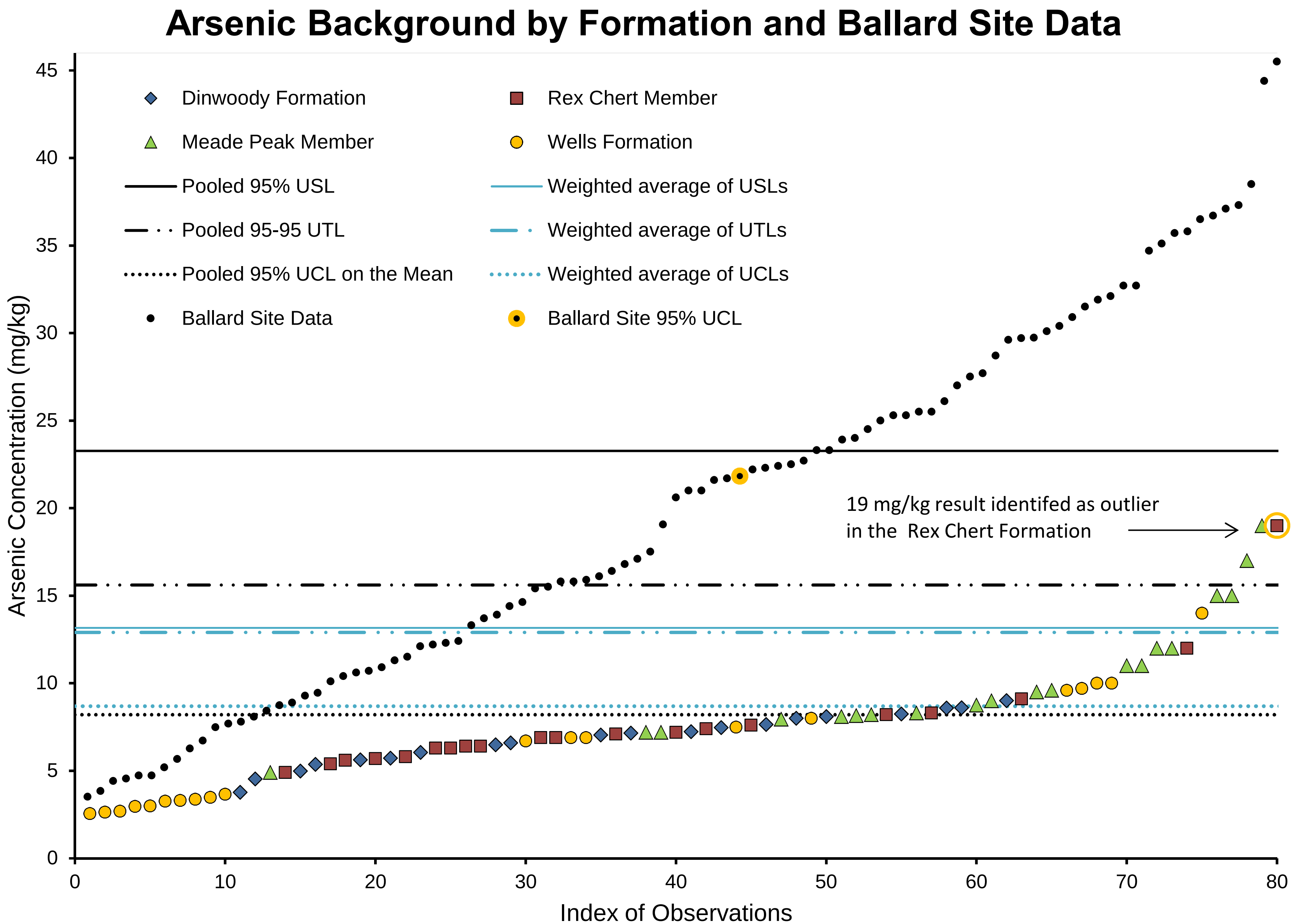
Upland Soil LCOC	Cattle
Selenium	24.8

Notes:

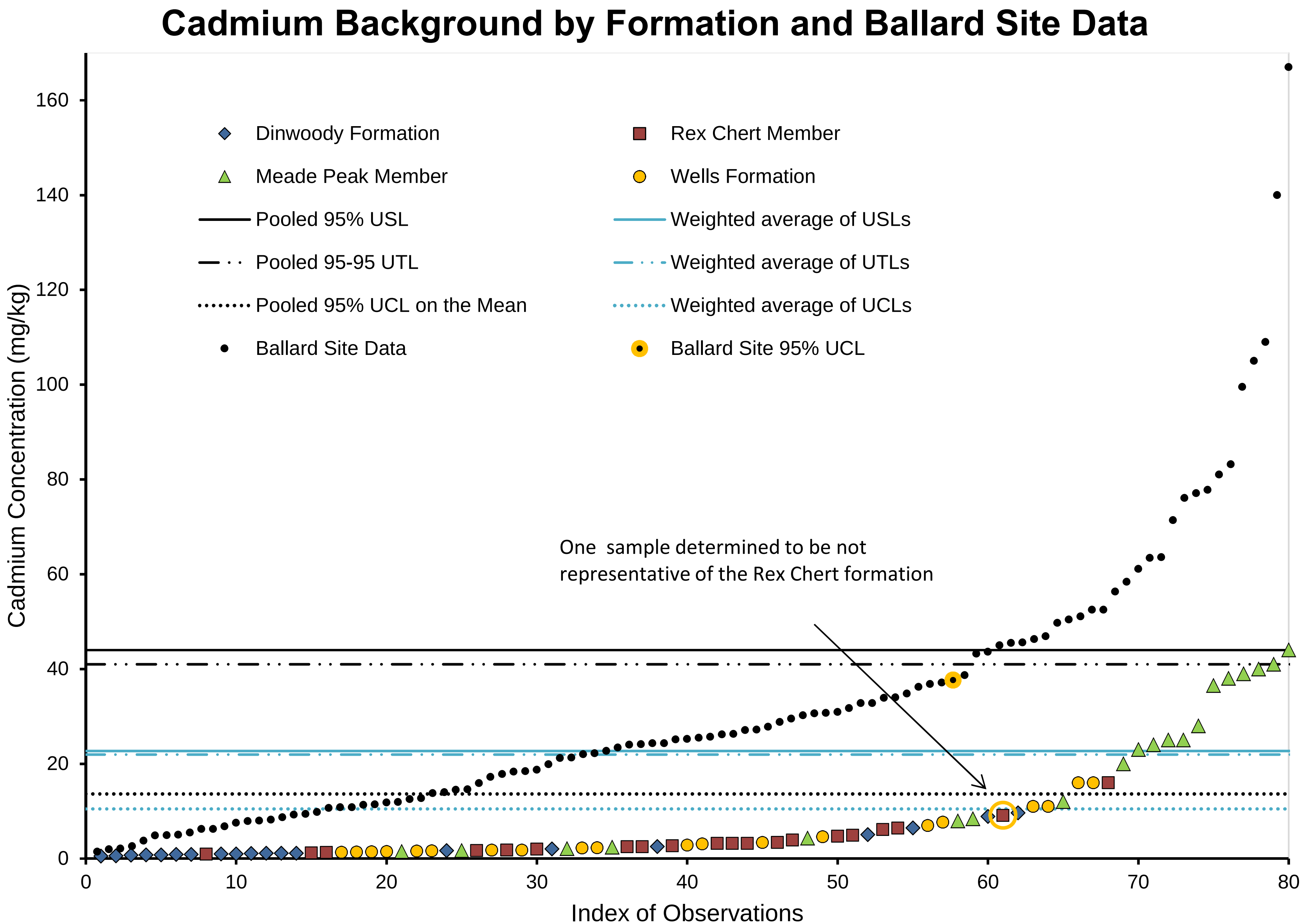
Concentration is in milligrams per kilogram (mg/kg).

LCOC - livestock chemical of concern

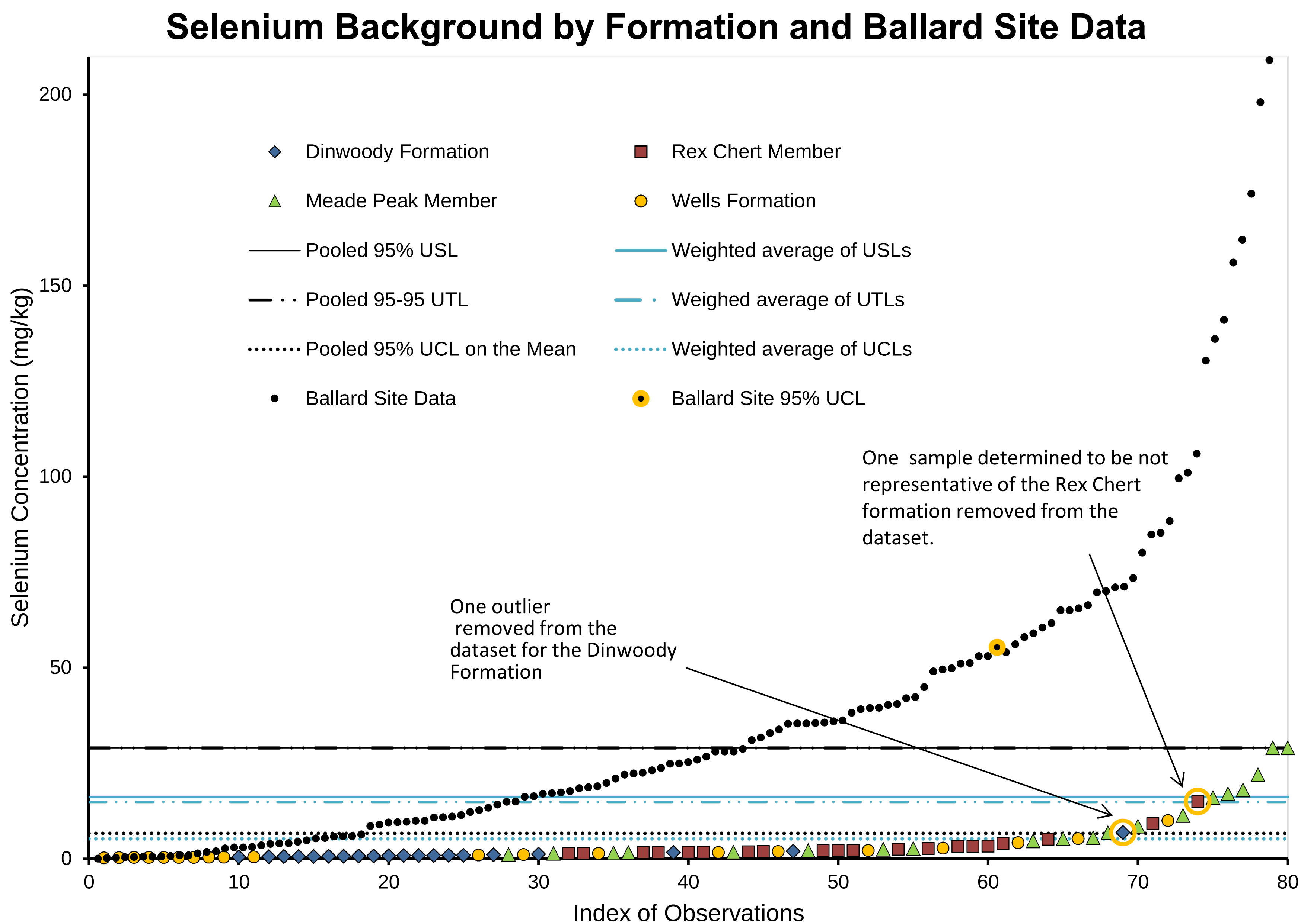
ATTACHMENT 1



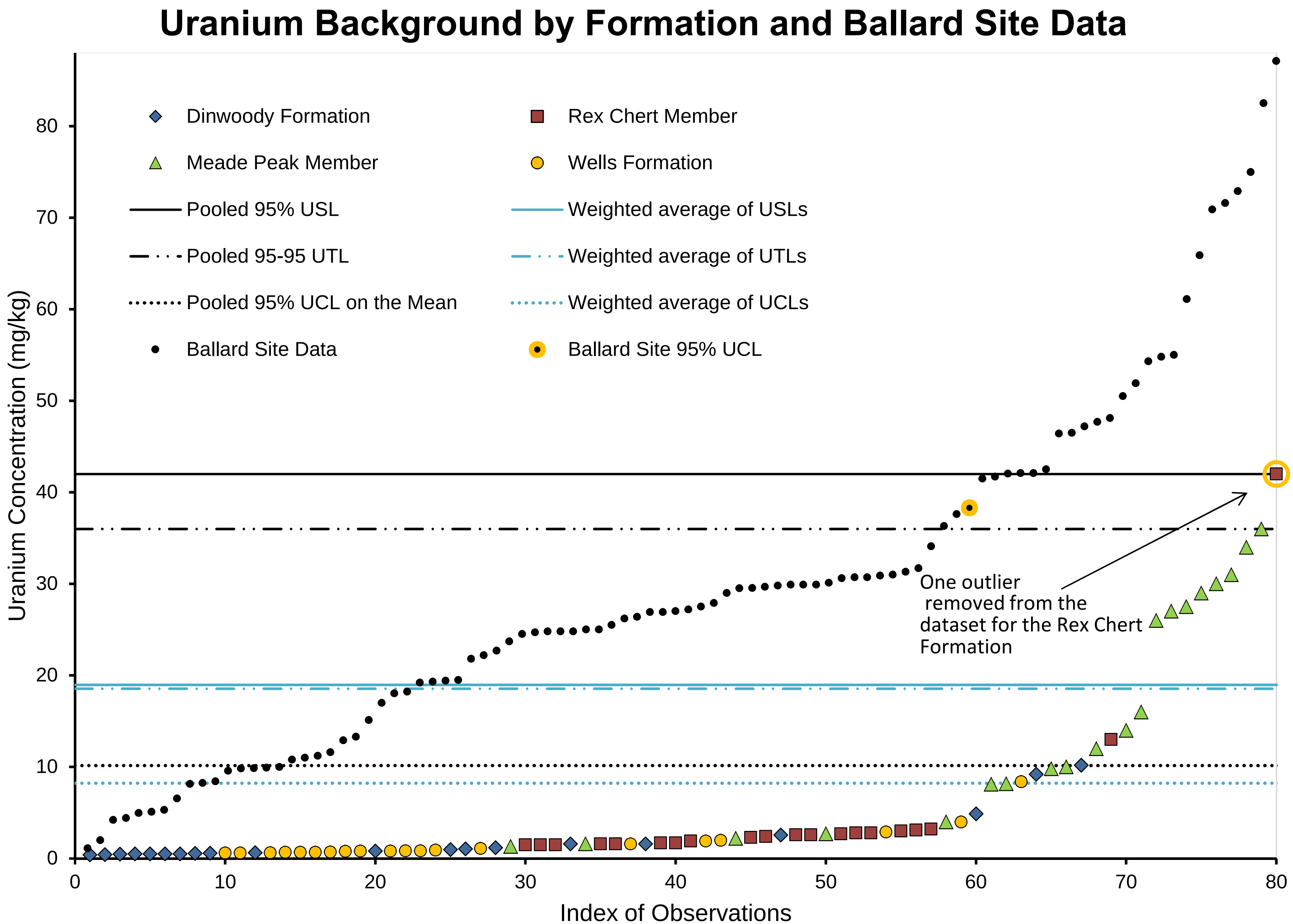
Arsenic Background by Formation and Ballard Site Data
Dinwoody Formation
Rex Chert Member
Meade Peak Member
Wells Formation
Pooled 95% USL
Weighted average of USLs
Pooled 95-95 UTL
Weighted average of UTLs
Pooled 95% UCL on the Mean
Weighted average of UCLs
Ballard Site Data
Ballard Site 95% UCL
19 mg/kg result identifed as outlier
in the Rex Chert Formation
Arsenic Concentration (mg/kg)
Index of Observations
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50
60
70
80



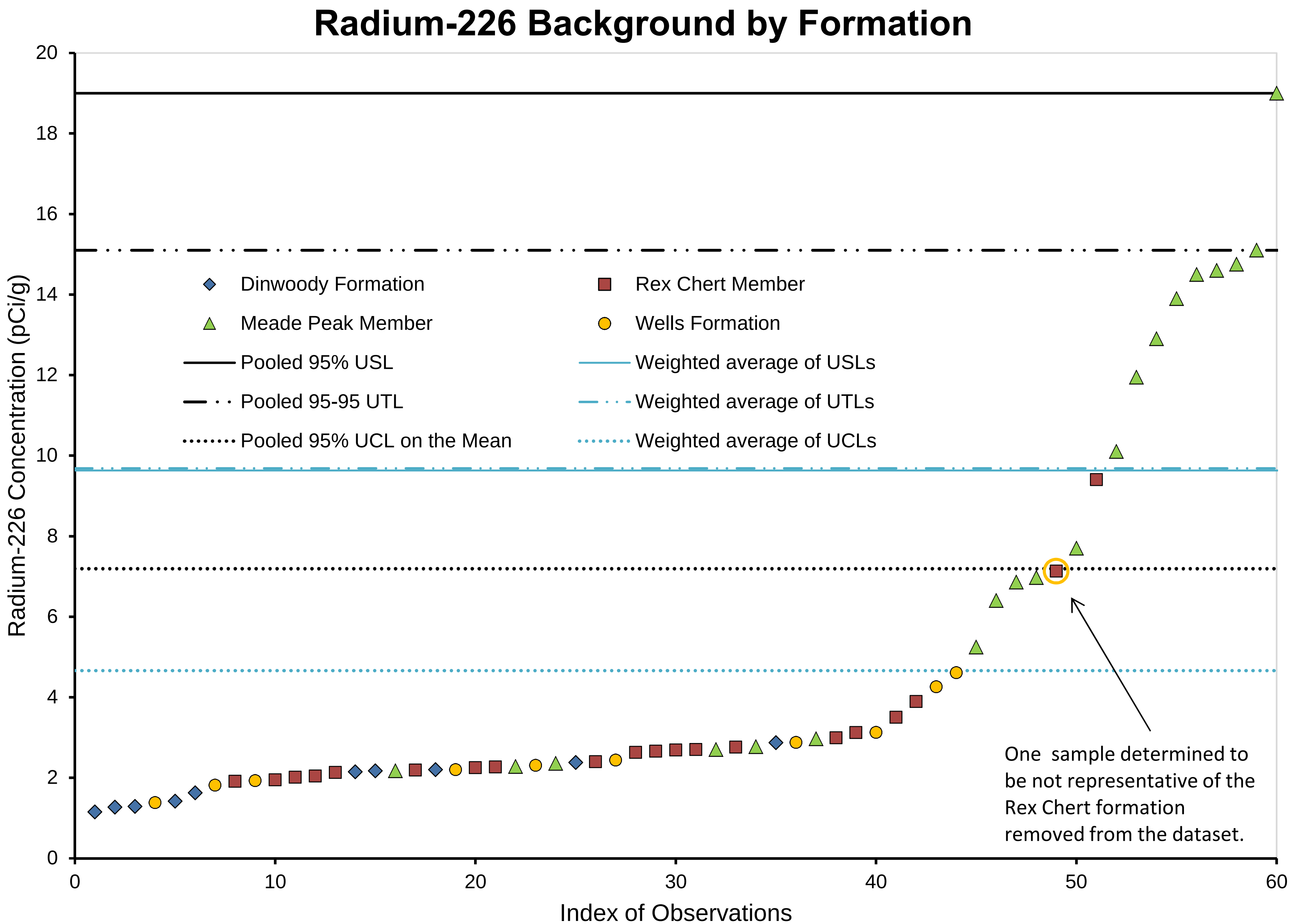
Cadmium Background by Formation and Ballard Site Data
Cadmium Concentration (mg/kg)
Index of Observations
0
20
40
60
80
100
120
140
160
0
10
20
30
40
50
60
70
80
Dinwoody Formation
Rex Chert Member
Meade Peak Member
Wells Formation
Pooled 95% USL
Weighted average of USLs
Pooled 95-95 UTL
Weighted average of UTLs
Pooled 95% UCL on the Mean
Weighted average of UCLs
Ballard Site Data
Ballard Site 95% UCL
One sample determined to be not
representative of the Rex Chert formation



Selenium Background by Formation and Ballard Site Data
Selenium Concentration (mg/kg)
Index of Observations
0
50
100
150
200
0
10
20
30
40
50
60
70
80
Dinwoody Formation
Rex Chert Member
Meade Peak Member
Wells Formation
Pooled 95% USL
Weighted average of USLs
Pooled 95-95 UTL
Weighed average of UTLs
Pooled 95% UCL on the Mean
Weighted average of UCLs
Ballard Site Data
Ballard Site 95% UCL
One sample determined to be not representative of the Rex Chert formation removed from the dataset.
One outlier removed from the dataset for the Dinwoody Formation



Uranium Background by Formation and Ballard Site Data
Dinwoody Formation
Rex Chert Member
Meade Peak Member
Wells Formation
Pooled 95% USL
Weighted average of USLs
Pooled 95-95 UTL
Weighted average of UTLs
Pooled 95% UCL on the Mean
Weighted average of UCLs
Ballard Site Data
Ballard Site 95% UCL
One outlier removed from the dataset for the Rex Chert Formation
Uranium Concentration (mg/kg)
Index of Observations
0
10
20
30
40
50
60
70
80



Radium-226 Background by Formation
Radium-226 Concentration (pCi/g)
Index of Observations
0
2
4
6
8
10
12
14
16
18
20
0
10
20
30
40
50
60
Dinwoody Formation
Rex Chert Member
Meade Peak Member
Wells Formation
Pooled 95% USL
Weighted average of USLs
Pooled 95-95 UTL
Weighted average of UTLs
Pooled 95% UCL on the Mean
Weighted average of UCLs
One sample determined to be not representative of the Rex Chert formation removed from the dataset.

Appendix B
Details of Final Remedial Technology Screening

FINAL

MAY 2016

Prepared by
MWH

Prepared for:
P4 Production, LLC

TABLE OF CONTENTS

This appendix presents detailed information regarding the further screening of remedial technologies that is summarized in Section 5.0. As discussed in the introduction to Section 5.0, the potentially applicable remedial technologies and associated process options that were retained based on the preliminary screening of technical implementability are further screened and retained or eliminated in accordance with the *RI/FS Guidance*. The goal of this final technology-screening step is to further reduce the number of retained process options to a subset consisting of only the most viable technologies for the development of remedial alternatives for each environmental medium at the Site.

B.1 TECHNOLOGY SCREENING FOR VEGETATION

As discussed in Section 4.2.3, vegetation is considered a secondary medium in that plants uptake COCs/COECs from primary media such as soil, sediment, surface water and/or groundwater. As a result, remedial technologies are not evaluated specifically for the Site vegetation. Instead, vegetation is included as a consideration in the technology screening performed for each primary medium discussed in this section.

B.2 TECHNOLOGY SCREENING FOR UPLAND SOIL AND WASTE ROCK

In this section, the retained technologies and process options that were preliminarily screened in Section 4.1 are further screened against the effectiveness, implementability, and cost criteria. The rationale for retaining or eliminating each technology is presented below and summarized in **Table 5-1**.

B.2.1 No-Action

The No-Action option is always carried forward as a baseline case in the FS process and is required by the NCP, as discussed in the *RI/FS Guidance*. Evaluation of this option against the three screening criteria and additional Site considerations is presented below.

Effectiveness: Low. No reduction in the toxicity, mobility, or volume of COCs/ROCs/COECs in upland soil, associated vegetation, or waste rock. The No-Action alternative is not effective for constituents that drive unacceptable risk or exceed the RAOs.

Implementability: High. The No-Action option is easily implementable because nothing changes in the management of the Site.

Cost: Low. No additional capital costs, no O&M costs.

Site-Specific Considerations: The No-Action alternative is not appropriate in the upland soil/waste rock where there are unacceptable risks.

Potentially Applicable Areas: The No-Action alternative is only applicable to areas of the Ballard Site that meet the RAOs.

Decision Rationale: Evaluation of the No-Action alternative is required by the NCP as a point of comparison with other alternatives.

Retained?: Yes. Although the No-Action alternative does not reduce risks or meet RAOs, it is retained as point of comparison as required by the NCP.

B.2.2 Limited Action Response

The Limited Action Response options that are applicable to the upland soil/waste rock include ICs as discussed in Section 4.2.4.1. ICs assist in achieving RAOs by: 1) limiting land or resource use/access, and 2) providing information that helps modify or guide human behavior at locations and in areas where COC/ROC concentrations prevent unlimited use and unrestricted exposure. ICs also are used to prevent exposures during the period between when an active remedy is implemented and the cleanup levels are achieved, and to prevent activities that would interfere with an implemented remedy (e.g., excavating in a capped area). The ICs that are applicable to the upland soil/waste rock include proprietary controls, governmental controls, and fencing.

- **Proprietary Controls and Governmental Controls**. Proprietary controls (also known as deed restrictions) such as easements and restrictive covenants are the most applicable type of non-engineered ICs to restrict certain activities on P4 property and the adjacent privately owned property. Governmental controls (e.g., zoning, local ordinances) are the most applicable type of non-engineered ICs to restrict certain activities on adjacent state and federal lands.

  Effectiveness: High when combined with other remedial technologies. ICs alone do not reduce the toxicity, mobility, or volume of COCs/ROCs/COECs in upland soil, associated vegetation, or waste rock; and are not effective in reducing risk to environmental receptors. Effective at prohibiting designated types of land (e.g., residential development) use through legal mechanisms such as deed restrictions, covenants, and environmental easements that have continuing effect in perpetuity or until occurrence of a defined terminating event.

Implementability: Moderate. Proprietary controls are relatively easy to implement within the Ballard Site boundary that is controlled by P4 Production. Proprietary and governmental controls may be more difficult to implement on state, federal, or privately owned property adjacent to the Site if necessary (refer to **Drawing 1-2** that shows the land ownership surrounding the Ballard Mine Site).

Cost: Low capital, low O&M.

Site-Specific Considerations: There are no Site-specific considerations that would inhibit establishing proprietary and governmental controls other than obtaining the cooperation of the adjacent landowners.

Potentially Applicable Areas: Proprietary and governmental controls are potentially applicable to all impacted areas of upland soil/waste rock.

Decision Rationale: Proprietary and governmental controls are retained because they would be effective at limiting access and direct human exposure to COCs/ROCs in upland soil, associated vegetation, and waste rock on the Site. ICs are typically a component of a selected remedial alternative.

Retained?: Yes.

- **Fencing**. Fencing can be erected as an engineered control to prevent human, livestock, and other large-animal access to areas that have unacceptable risks. By limiting access to specific areas, fencing contributes to a reduction of risk by reducing the potential for exposure through direct contact with COCs/ROCs/COECs. However, it does not reduce the toxicity, mobility, or volume of the COCs/ROCs/COECs.

  Effectiveness: High when combined with other remedial technologies. Fencing alone does not reduce the toxicity, mobility, or volume of COCs/ROCs/COECs in upland soil, associated vegetation, or waste rock. For some receptors, fencing would be effective for prevention of direct contact with all Site COCs/ROCs/COECs in upland soil, associated vegetation, and waste rock. Fencing does not address minimizing infiltration of precipitation at potential sources of constituent migration to groundwater.

  Implementability: High. The design and construction of new fencing or updates to existing fencing is straightforward to implement. Construction of new fencing or a different type of fencing on State or privately owned property may be difficult because of long-term agreements that have to be negotiated.

Cost: Low capital, low O&M. Costs would include design, construction, periodic inspections/O&M and 5-year review reporting.

Site-Specific Considerations: Fencing is already in place around portions of the Site perimeter, although some fence improvements and additional fencing may be required.

Potentially Applicable Areas: Fencing is potentially applicable to all upland soil/waste rock areas that have unacceptable risks.

Decision Rationale: Fencing is retained because it would effectively limit access and exposures to some receptors. Fencing typically is a component of a selected remedial alternative.

Retained?: Yes.

B.2.3 Containment

B.2.3.1 Cover Systems

Cover systems consist either of single or multi-layer earthen or multi-layer composite (i.e., earthen and/or geosynthetic) systems to cap impacted areas of the Site. Capping is a readily implementable and a proven technology for eliminating direct exposure of humans and ecological receptors to Ballard Site COCs/ROCs/COECs, in addition to minimizing potential future impacts to groundwater. However, a given cap's effectiveness at achieving these objectives is based on its structural components, which in turn affect the cost of implementing a given cap design. The cost of each cap design must be weighed against the limitations of its design (i.e., effectiveness) to determine which cap design is the most cost-effective while achieving the necessary reduction in risk. The following three primary performance criteria were used in the effectiveness evaluations for each cover type considered.

1. Preventing Direct Exposure
2. Reducing Infiltration
3. Long-Term Durability

The following cover types, identified in Section 4.2.4.2, typically are designed for specific objectives that may limit their applicability only to certain types of contamination and specific areas of the Site.

- **Multi-Layered (Conventional) Cap**. The multi-layered cap involves construction of a cap with at least one hydraulic-barrier layer, consisting of either a compacted clay layer, GCL, or geomembrane layer. In addition to the hydraulic-barrier layer, the cap would incorporate a drainage layer and a vegetation layer. Installing a clay layer may require importing large quantities of material in the event that local sources are not available. An alternative to a compacted clay layer would involve using some type of geomembrane/GCL or crushed limestone layer to serve as the hydraulic-barrier layer.

  Effectiveness: High.

  1. Preventing Direct Exposure – When implemented with ICs that prevent access and future disturbance of the cap, the multi-layered cap is effective for reducing direct exposure and ingestion for all COCs/ROCs/COECs.
  2. Reducing Infiltration – As long as cap integrity is maintained, a multi-layered cap is effective at reducing infiltration and potential migration of COCs/COECs to groundwater.
  3. Long-Term Durability – The potential for significant damage during placement brings into question the long-term durability of multi-layered caps. An O&M plan to monitor the cap vegetation and cap materials would be required to ensure long-term durability and effectiveness.

  Implementability: Moderate. The design and construction of multi-layer caps is more complex than other types of caps, i.e., several layers are required including compacted clay and/or synthetic liners. Multiple cap designs for different areas of the Site may be required depending on the mobility of the COCs/ROCs/COECs being capped and downstream receptors.

  Cost: High capital, moderate O&M. Costs would include design, construction, periodic inspections/O&M, and 5-year review reporting.

  Site-Specific Considerations: A multi-layered cap is a potential option for upland soil/waste rock areas with potential groundwater impacts from all Site-related COCs. Access restrictions to limit cap intrusion and resulting exposure to underlying waste rock/contaminated soil would also be required. Existing vegetation will need to be removed and consolidated into upland soil or waste rock that receives the cover. In addition, vegetation to be planted within the vegetative layer would preclude plant species that are considered selenium hyperaccumulators.

Potentially Applicable Areas: Multi-layer caps are applicable to areas with potential groundwater impacts (i.e., West Ballard Pit) from Site COCs. May include multiple designs based upon mobility and risk posed by the specific COCs/ROCs/COECs being capped.

Decision Rationale: Multi-layer caps are retained because they would be effective for protection of groundwater and minimizing direct exposure and ingestion of all Site COCs/ROCs/COECs when implemented in conjunction with ICs (e.g., fencing and deed restrictions).

Retained?: Yes.

- **Evapotranspirative (ET) Cap**. An ET cap involves constructing an earthen cover of soil and vegetation to provide sufficient water storage and ET capacity to store and remove precipitation, thereby eliminating infiltration through the cover and into the underlying waste. ET cover systems may be monolithic or include a capillary-break layer comprised of coarse material (e.g., cobbles) that limits infiltration into the underlying wastes. ET soil caps have been widely used in arid and semi-arid regions of the western United States and have been effective at eliminating infiltration of precipitation and isolating waste (USEPA 2003). However, due to the elevation of the Site and relatively high precipitation rates (snowfall), an ET cap may not be as effective as other cover systems. Additional testing during the remedial design phase would be required to confirm that an ET cap would be effective at the Ballard Site.

  Once established, an ET cover may provide greater long-term protection because of its use of geological materials, which are very durable, rather than synthetic materials (i.e., flexible membrane liners), which can fail over time.

  Effectiveness: High.

1. Preventing Direct Exposure – When implemented in conjunction with deed restrictions that prevent future disturbance of the cap, the ET cap is effective for reducing direct exposure and ingestion for all COCs/ROCs/COECs.

2. Reducing Infiltration – As long as cap integrity is maintained, an ET cap is effective at reducing infiltration and potential migration of COCs to groundwater.

3. Long-Term Durability – Because ET caps are constructed of earthen materials, long-term durability is believed to be superior to multi-layered caps. An O&M plan to monitor the ET cap vegetation and cap materials would be required to ensure long-term durability and effectiveness.

Implementability: High. The design and construction of ET caps is considered straightforward. ET caps typically use locally sourced soil and native vegetation.

Cost: Moderate to High capital (if on-site borrow sources are available) and low O&M costs. Costs would include design, construction, periodic inspections/O&M and 5-year review reporting.

Site-Specific Considerations: The specific design will be based on performance criteria that would include eliminating future groundwater impacts and direct exposure of Site COCs/ROCs/COECs. Infiltration modeling would be necessary to establish the overall thickness of an ET cover system and at this location the ET cap might be fairly thick because of Site specific conditions (altitude, precipitation amount and timing of precipitation and snowmelt, etc.). An ET cap would be used with ICs to limit exposure to underlying wastes/contaminated soil and potential intrusions to the cap. Existing vegetation will need to be removed and consolidated into upland soil or waste rock that receives the cover. In addition, vegetation to be planted within the vegetative layer would not include plant species that are considered selenium hyperaccumulators.

Potentially Applicable Areas: ET caps are potentially applicable to all areas of the Site with waste rock, or specific areas that are known sources of potential groundwater impacts.

Decision Rationale: ET caps are retained because they are increasingly being used in arid and semi-arid regions to prevent future groundwater impacts and to minimize direct exposure and ingestion of Site COCs/ROCs/COECs when applied with ICs (e.g., fencing and deed restrictions).

Retained?: Yes.

- **Soil Cover Cap**. A soil cover cap involves placement of one foot or more of soil over impacted soil or waste rock to limit contaminant migration and gamma exposure. Gamma caps or simple soil cover caps typically reduce but do not eliminate infiltration of precipitation and therefore may not eliminate the potential for leaching of metals.

  Effectiveness: High, but for only for gamma/direct contact exposure.

  1. Preventing Direct Exposure – One foot or more of native soil cover has been shown to be effective at reducing gamma radiation from ROCs to acceptable levels. This cover also limits direct contact exposure to other COCs (e.g., ingestion, dermal contact, and inhalation) if implemented with sufficient deed/access restrictions.
  2. Reducing Infiltration –Soil caps having one-foot thickness likely are not effective for eliminating infiltration, but may still reduce leaching of metals from the soil/waste rock.
  3. Long-Term Durability – Because soil caps are constructed of earthen materials, long-term durability is presumed to be superior to caps that include synthetic materials.

  Implementability: High. The design and construction of soil caps is straightforward. Soil covers typically use locally sourced soil and native vegetation.

  Cost: Low capital (if on-site borrow sources are available) and low O&M costs. Costs would include design, construction, periodic inspections/O&M and 5-year review reporting. Costs are low because the thickness of soil is determined by its ability to reduce direct exposure to COCs/ROCs and not to completely eliminate leaching of COCs/COECs from the underlying waste rock (i.e., necessary for ET cover)

  Site-Specific Considerations: Soil cover caps could be considered for areas on Site to address gamma radiation from ROCs and direct contact with COCs. Similar to the other capping options, soil cover caps would be used in conjunction with access restrictions to limit exposure to underlying waste rock/contaminated soil. Existing vegetation will need to be removed and consolidated into upland soil or waste rock that receives the cover. In addition, vegetation to be planted to reclaim the surface of the cap would not include plant species that are considered selenium hyperaccumulators.

Potentially Applicable Areas: Potentially applicable to areas with COCs/ROCs posing direct contact risk.

Decision Rationale: Soil cover caps are retained because they would be effective in addressing direct contact risk associated with COCs/ROCs and would reduce the extent of infiltration and leaching from metal-containing waste rock and soil.

Retained?: Yes

B.2.3.2 Surface Control

- **Soil Grading**. Surface grading involves the control and routing of stormwater run-on and runoff in order to reduce ponding and infiltration of surface water in the impacted upland soil/waste rock.

  Effectiveness: High when combined with other remedial technologies. Surface grading is effective for reducing infiltration by promoting drainage of storm water run-on/runoff away from capped or impacted areas. Surface grading alone would not reduce the toxicity, or volume of COCs/ROCs/COECs in upland soil/waste rock or vegetation, but could act to reduce the mobility of COCs/ROCs/COECs by limiting infiltration and erosion. Likewise, surface grading alone is not effective in reducing direct exposures to human and environmental receptors.

  Implementability: High. Surface grading is straightforward. Surface grading would be incorporated into overall Site restoration grading plan.

  Cost: Low capital and O&M costs. Costs would include grading design, construction, periodic inspections/O&M and 5-year review reporting.

  Site-Specific Considerations: The topography of the Site is conducive to using soil grading to divert a portion of surface water flow away from the impacted upland soil/waste rock.

  Potentially Applicable Areas: Site-wide grading would be applicable to all areas of impacted upland soil/waste rock.

  Decision Rationale: Soil grading is retained, but only as a component of an overall remedy that meets RAOs. For example, site-wide draining would be a design consideration for controlling surface water flow on and around a cap or cover system.

  Retained?: Yes.

B.2.4 Removal and Disposal

B.2.4.1 Removal

Removal, followed by some form of appropriate disposal, is a proven method for effectively removing COCs/ROCs/COECs to a level below risk-based standards.

- **Conventional Excavation**. Conventional excavation involves the removal of impacted soil and waste rock through the use of conventional excavation equipment including trackhoes, dozers, front loaders, and scrapers.

  Effectiveness: High. Removal of impacted upland soil/waste rock and vegetation via conventional excavation would eliminate the unacceptable risks and would meet the chemical-specific ARARs assuming the excavated materials are properly disposed. (The on-Site disposal options are discussed below.)

  Implementability: High. Straightforward using conventional excavation in areas with COCs/ROCs/COECs.

  Cost: High capital, no O&M costs. Costs would include excavation design, periodic inspections during implementation. Excavated areas would be reclaimed through revegetation. Therefore, O&M costs are associated with other process options.

  Site-Specific Considerations: The upland soil/waste rock areas are conducive to using conventional excavation equipment to remove the impacted materials.

  Potentially Applicable Areas: Conventional excavation would be applicable to areas of impacted upland soil/waste rock and associated vegetation.

  Decision Rationale: Conventional excavation is retained as potentially applicable in conjunction with other treatment, disposal, or reuse options. Conventional excavation would be required in conjunction with on-Site consolidation and reuse, or on-Site disposal (i.e., backfilling of existing pits) as discussed below.

  Retained?: Yes.

B.2.4.2 Disposal

Disposal of impacted upland soil (including vegetation) and waste rock would have to be considered as part of any remedial alternative involving removal. Off-Site disposal was eliminated in the initial screening step described in Section 4.2.4.3. Evaluation of on-Site disposal against the three screening criteria and additional Site considerations is presented below.

- **On-Site Disposal**. On-site disposal involves consolidation of excavated materials in on-Site open mine pits or in a selected area adjacent to the pit that will eventually receive caps/soil covers. To ensure long-term isolation of the excavated materials and prevent future groundwater impacts, the consolidated upland soil/waste rock/vegetation would require placement in an area that would receive an appropriate grading and cover/cap for the COCs/ROCs/COECs present.

  Effectiveness: High. Effective at reducing impacted footprint at the Site by consolidation and subsequent capping of the impacted upland soil/waste rock and associated vegetation.

  Implementability: High. On-Site disposal would be relatively straightforward using conventional earthwork equipment.

  Cost: Moderately high capital and low to moderate O&M costs. Costs would include design, construction, periodic construction inspections/O&M and 5-year review reporting.

  Site-Specific Considerations: The layout of the Site (e.g., existing mine pits) is conducive to the consolidation and capping of the potentially large volumes of excavated wastes.

  Potentially Applicable Areas: On-Site disposal would be applicable to all areas of the Site containing impacted upland soil/waste rock.

  Decision Rationale: On-Site disposal is retained because removal and on-Site disposal may be the most feasible method for remediating the large volumes of upland soil/waste rock.

  Retained?: Yes.

B.3 TECHNOLOGY SCREENING FOR SURFACE WATER

In this section, the retained technologies and process options that were preliminarily screened in Section 4.3 are further screened against the effectiveness, implementability, and cost criteria. The rationale for retaining or eliminating each technology is presented below and summarized in **Table 5-2**.

B.3.1 No Action

The No-Action option is being retained because it is required to be evaluated as a base case by the NCP and under current *RI/FS Guidance*. Evaluation of the No-Action option against the three screening criteria as well as additional site considerations is presented below.

Effectiveness: Low. The no-action alternative is not effective for constituents that drive unacceptable risk or exceed ARARs.

Implementability: High. The No-Action alternative is easy to implement.

Cost: Low (no additional) capital costs, no O&M costs.

Site-Specific Considerations. The No-Action alternative is not appropriate where COC/COEC concentrations exceed the surface water ARARs.

Potentially Applicable Areas: The No-Action alternative is potentially applicable where COC/COEC concentrations do not exceed the surface water ARARs.

Decision Rationale: Yes. Although the No-Action alternative does not reduce risks or meet chemical-specific ARARs for the Site surface water, it is retained as point of comparison as required by the NCP.

Retained?: Yes.

B.3.2 Limited Action Response

Limited action responses applicable to the Site surface water include ICs to limit surface water use, prevent exposures for some receptors, and to protect the integrity of remedial actions.

B.3.2.1 Institutional Controls

As discussed in Section 4.3.4.1, ICs assist in achieving RAOs by: 1) limiting land or resource use/access, and 2) providing information that helps modify or guide human behavior at locations and in areas where COC/COEC concentrations prevent unlimited use and unrestricted exposure. ICs also are used to prevent exposures during the period between when an active remedy is implemented and the cleanup levels are achieved. The ICs that are applicable to the impacted surface water at the Ballard Site include governmental and proprietary controls to restrict groundwater use, and fencing to restrict access to impacted surface water.

- **Proprietary Controls and Governmental Controls**. Proprietary controls (also known as deed restrictions) such as easements and restrictive covenants are the most applicable type of non-engineered ICs to restrict certain activities on P4 property and the adjacent privately-owned property. Governmental controls (e.g., zoning, local ordinances) are the most applicable type of non-engineered ICs to restrict certain activities on adjacent state and federal lands.

  Effectiveness: High when combined with other remedial technologies. ICs alone do not reduce the toxicity, mobility, or volume of COCs/COECs in surface water; and are not effective in reducing risk to environmental receptors. ICs would potentially be effective in preventing human exposure to surface water COCs (e.g., consumption, irrigation).

  Implementability: Moderate. Proprietary controls are relatively easy to implement within the Ballard Site boundary that is controlled by P4 Production. Proprietary and governmental controls may be more difficult to implement on state, federal, or privately-owned property adjacent to the Site if necessary (see **Drawing 1-2** that shows the land ownership surrounding the Ballard Mine Site).

  Cost: Low capital, low O&M.

  Site-Specific Considerations: There are no Site-specific considerations that would inhibit establishing proprietary and governmental controls other than obtaining the cooperation of the adjacent landowners.

  Potentially Applicable Areas: Proprietary and governmental controls are potentially applicable to all areas of impacted surface water.

  Decision Rationale: Proprietary and governmental controls are retained because they would be effective at limiting access and direct human exposure to COCs in the impacted surface water. ICs are typically a component of an overall Site remedy.

  Retained?: Yes.

- **Fencing**. Fencing can be erected as an engineered control to prevent human, livestock, and other large-animal access to areas that have unacceptable risks. Small animals and birds are more difficult to restrict with fencing, but it is possible for small areas. By limiting access to specific areas, fencing contributes to a reduction of risk by reducing the potential for exposure through direct contact with COCs/COECs. However, it does not reduce the toxicity, mobility, or volume of the COCs/COECs, and does not reduce risks to aquatic receptors.

Effectiveness: High when combined with other remedial technologies. Fencing alone does not reduce the toxicity, mobility, or volume of COCs/COECs in surface water. For some receptors, fencing would be effective for prevention of direct contact with Site COCs/COECs in surface water.

Implementability: High. Design and construction of perimeter fencing would be easy to implement.

Cost: Low capital, low O&M. Costs would include design, construction, periodic inspections/O&M and 5-year review reporting.

Site-Specific Considerations: Site-specific considerations for constructing a fence include obtaining the cooperation of the affected private landowners, and the perceived aesthetic impacts of a fence.

Potentially Applicable Areas: Fencing is applicable to all areas of impacted surface water that have unacceptable risks.

Decision Rationale: Fencing is retained because it would effectively limit access and exposures to some receptors. Fencing typically is a component of an overall Site remedy.

Retained?: Yes.

B.3.3 Source Controls

Source controls are an effective way for reducing migration of COCs/COECs from source areas to surface water by removing or containing the source of surface water impacts. Source controls can include treatment of source areas through containment (capping), treatment and/or removal. The technologies associated with source controls are discussed as part of the remedial technologies for upland soil/waste rock (see Section B.2). Key source controls for surface water are those that prevent surface water contact with Site waste rock, and those that reduce or eliminate mine waste rock seepage containing elevated COC/COEC concentrations. Evaluation of the source control option against the three screening criteria and additional Site considerations is presented below.

Effectiveness: Moderate to high. Source controls can be highly effective for reducing storm water contact with the primary source (waste rock). The effectiveness of source controls for reducing COC/COEC concentrations is seeps and springs is likely to be more variable, increasing with time. Some additional actions may be necessary to treat impacted seep/spring discharge for a period immediately after implementation of the source controls.

Implementability: Low to high. Refer to the upland soil/mine waste discussion in Section B.2.

Cost: Moderate to high capital, low to moderate O&M.

Site-Specific Considerations. See Section B.2.

Potentially Applicable Areas: See Section B.2.

Decision Rationale: Source controls can include treatment of source areas through containment (capping), in-situ treatment, and/or removal. The technologies associated with source controls are discussed as part of remedial technologies for upland soil/waste rock (see Section B.2). Source controls have the potential for requiring the least amount of long-term O&M with high permanence.

Retained?: Yes.

B.3.4 Containment

Complete containment of surface water on Site is not a practicable technology. However, temporary containment is an important consideration to reduce the concentrations of some COCs/COECs in the suspended phase. In addition, suspended sediment control would be required during remedial construction and until any revegetation is shown to be complete. Containment will only supplement the overall remedial action at the Site, but it is an important component for limiting the migration of COCs/COECs in the suspended phase and as bedload sediment. Two relevant technologies are evaluated below.

B.3.4.1 Retention Basins

Retention basins or sedimentation pond, are a common BMP for storm water management and are used at most of the recent and active mines in the region. Typically, the ponds are formed by constructing a small earthen berm in a drainage. The intent is to slow or hold the water and thereby allowing the suspended sediment to settle out. During a large storm event, the ponds may discharge, but during smaller events, all the water may be retained. Any retained water either evaporates or infiltrates. If the water has elevated concentrations of COCs/COECs, this could be a source to groundwater if the basin is unlined. An example of this is pond MSP013 at the Site.

Effectiveness: Moderate. Can be very effective in settling suspended sediment and reducing total COC/COEC concentrations except during very large storm events. Typically, not effective for reducing dissolved COC/COEC concentrations.

Implementability: High. Retention basins are easily constructed and maintained.

Cost: Low capital, low O&M. Ponds may need periodic sediment removal.

Site-Specific Considerations. Retaining contaminated surface water in unlined retention basins may result in COCs/COECs being transferred to sediments and groundwater.

Potentially Applicable Areas: Retention basins are applicable to all areas where contaminated surface water is known or expected to flow off-Site.

Decision Rationale: Retention basins are a standard BMP that likely will be needed during remedial construction, and to help reduce the transport of COCs/COECs off Site.

Retained?: Yes.

B.3.4.2 Wetlands

Wetlands function like retention basins, but are vegetated with wetlands plants. Wetlands can have an added benefit in some removal of dissolved COCs/COECs due to biological activity.

Effectiveness: Moderate. Wetlands are slightly more effective than retention basins due to the additional filtration provided by the vegetation and possible dissolved COC/COEC removal due to biological activity.

Implementability: Low. Wetlands require a moist environment with standing water for at least several months of the year to support vegetation. Implementation on the Site would be difficult unless fed by a perennial seep or spring.

Cost: Low capital and low O&M.

Site-Specific Considerations: Site drainages are dry for much of the year and are not likely to support wetlands vegetation.

Potentially Applicable Areas: Surface drainages, and seep and spring locations throughout the Site.

Decision Rationale: Wetlands are not retained as a containment option because vegetation would have low survivability without a source of water besides storm water and runoff. Wetlands may have a role in seep and spring treatment discussed below in Section B.3.7.1.

Retained?: No.

B.3.5 Disposal

B.3.5.1 Land Application

For land application, the collected surface water is applied to a land area by irrigation. The water is lost to evaporation (from sprays and on the ground) and transpiration from plants. A small fraction will infiltrate to groundwater. COCs/COECs often will be fixated in the vegetation and soil so that the fraction that infiltrates to the groundwater has reduced COC/COEC concentrations. The concept works best in arid to semi-arid areas where there is a significant depth to groundwater that results in ample COC/COEC attenuation potential. Some level of water treatment could be required to address cross-media transfer of COCs/COECs, and potential percolation of COCs/COECs back to groundwater.

Effectiveness: Low. Land application is most effective during the spring to fall timeframe. The greatest surface water discharge from the Site occurs in the spring and early summer, so the seasonality of the source and process match well. Some level of treatment might be necessary to limit cross-media COC/COEC transfer, or infiltration of COCs/COECs to groundwater. Often, the attenuation capacity of the soil is sufficient to prevent groundwater contamination if the depth to groundwater is large enough. For surface water, effectiveness is limited because winter discharge from perennial springs would have to be stored or discharged by other means. In addition, long-term effectiveness is uncertain because of the potential COC/COEC accumulation in soil and vegetation may reach unacceptable levels.

Implementability: Low to moderate. Land application would require identification of a large tract of land with sufficient depth to groundwater (e.g., approximately 100 feet or more). Attenuation and cross-media transfer of COCs would have to be evaluated.

Cost: Low capital, moderate O&M.

Site-Specific Considerations: A large tract of land with sufficient depth to groundwater may not be available. Cross-media transfer of COCs/COECs (e.g., from the water to culturally significant plants) could result in transfer of risks. Cold weather would complicate land application in the winter.

Potentially Applicable Areas: Land application could be applicable to all surface water that is removed and treated.

Decision Rationale: The technology is potentially useful for surface water disposal, and the seasonal nature of land application matches well with the seasonal flow is the intermittent Site drainages, with the exception of some perennial spring discharge through the winter. In addition, a lower level of treatment may be acceptable compared to other disposal technologies. For example, in-stream standards may not apply, and COC/COEC concentrations higher than groundwater standards could be acceptable because of the capacity of the soil to attenuate COCs/COECs. A land application area containing surface water bodies would not be selected. However, there are a large number of uncertain factors in applying the technology, such as locating an appropriate tract of land and media transfer of COCs/COECs. Other technologies that also require some treatment have lower cost and more certainty.

Retained?: No.

B.3.5.2 Treated Discharge to Surface Water

This option would require interception of surface water (storm water, snow melt runoff, and spring and seep discharge), treatment, and discharge back to the surface water drainages. The volume of the water discharged to the surface water drainages would not change significantly, but the COC/COEC loading would be decreased to permitted levels. The discharge volume would be similar to current conditions, and the discharge from the Site drainages would not reach the Blackfoot River during large portions of the year.

Effectiveness: High. Effectiveness assumes surface water can be treated to meet NPDES permit requirements prior to discharge.

Implementability: High. A NPDES permit could be obtainable considering that the treated discharges would be similar to current flows, and because COC/COEC concentrations in the treated discharge would be below current concentrations, risk levels and ARARs.

Cost: Low to moderate capital, low O&M.

Site-Specific Considerations: Most Site surface water drainages flow to the Blackfoot River. The main stem of Blackfoot River from the confluence of Lanes and Diamond creeks to the

Blackfoot Reservoir is a 303(d)-listed segment for selenium, sediment, dissolved oxygen, and elevated temperature (*RI Report* – MWH, 2014). Obtaining NPDES permits for drainages that flow to the Blackfoot River could be difficult. However, the treated discharge in this case would result in reduced selenium loading in the Blackfoot River.

Potentially Applicable Areas: Could be applicable to all surface water that is removed and treated.

Decision Rationale: Treated discharge to surface water is retained because a NPDES permit could be obtainable considering that the volumes of treated discharges would be similar to current flows, and because COC/COEC concentrations in the treated discharge would be below current concentrations, risk levels and ARARs.

Retained?: Yes.

B.3.5.3 Evaporation/Infiltration Basin or Trench

Discharge to an evaporation/infiltration basin or trench would require some treatment of the surface water before it is discharged. Infiltration to the alluvial unit could be possible if an area with relatively high permeability is identified and/or if water volumes are relatively small. A basalt unit, which typically can have relatively high permeability because of fracturing, is present west of the Site in the valley and could be an option for an infiltration basin. Infiltration to the Wells Formation in the bottom of one of the mine pits would also be an option. Because a larger volume of water is generated in the spring, evaporation during the warm summer months could be a component for managing the spring runoff volume coupled with infiltration. However, evaporation is only seasonally effective and could not be relied on as the only disposal method. Evaluation of this option against the three screening criteria and additional Site considerations is presented below.

Effectiveness: Moderate to high. Effective for disposal of treated water assuming a location with sufficient infiltration capacity is identified. Evaporation would only be effective for water disposal during the warmer months. Infiltration into a permeable unit of the Wells Formation would be highly effective, as would infiltration into the fractured basalt unit. Infiltration to the alluvial unit could be effective if permeable strata are located.

Implementability: Moderate. Implementable, but would require treatment of surface water prior to discharge to the basin, but for some COCs, like selenium, the level of treatment could be less than for discharge to surface water (i.e., groundwater standards are higher than surface water standards). An investigation would be required to select a location for the system (storage and infiltration facility). The system would have to accommodate the seasonality of the flow with either excess infiltration capacity or storage. Removal of surface water from the local watershed could affect wetland habitats and require mitigation. If infiltration to the Wells Formation is considered, use of one of the mine pits could be a readily available location (shallow injection wells could be an option in this setting). Infiltration to the alluvial system may be possible for a small volume of water if permeable beds can be located. For infiltration into the fractured basalt, an agreement with an adjacent landowner would be required.

Cost: Moderate capital, low O&M.

Site-Specific Considerations: Disposal of collected surface water via an infiltration basin would require identifying an area with suitable permeability. Disposal of collected surface water via an evaporation basin would only be feasible during the warm summer months. Infiltration of Site surface water to groundwater would reduce flows in the associated watershed. The seasonal variability of Site surface water flow may make temporary storage of water necessary.

Potentially Applicable Areas: Could be applicable to all surface water that is removed and treated.

Decision Rationale: The infiltration of seasonal snowmelt and runoff would likely require a storage basin and would have a significant effect on the hydrology of the watershed. However, with source controls, impacted runoff is likely to be eliminated. Spring and seep discharges are less seasonally variable, have more predictable lower flow rates, and are fundamentally groundwater discharges. Only during runoff periods do these flows reach the Blackfoot River when comingled with runoff. Infiltration of spring and seep water back to the alluvial groundwater system, would not likely affect the hydrology of the watershed.

Retained?: Yes.

B.3.6 Ex-Situ Treatment

A detailed description of the ex-situ treatment technologies that were retained following the initial screening described in Section 4.3.4.5 is provided below. Prior to full-scale implementation, one or more of the technologies that would form the treatment train would need to be pilot tested to determine their effectiveness at reducing COCs/COECs to acceptable levels. Four general categories of ex-situ treatment technologies for surface water are evaluated below including physical, chemical, thermal, and biological categories and their associated process options.

B.3.6.1 Physical

- **Solid/Water Separation.** Separation consists of mechanical and gravity methods for bulk removal of suspended solids from surface water. Considering that most of the surface water COCs/COECs exceeding ARARs are in the dissolved phase, separation would not be sufficient as a standalone technology, but could be incorporated into the treatment train of a larger treatment system. For example, a clarifier is often a component of a chemical precipitation process to gravity separate the newly formed solid contaminants. Chemical processes such as lime softening and coagulation both generate large volumes of solids that need to be separated from the treated water stream.

  Effectiveness: High if used in conjunction with other treatment technologies that precipitate dissolved COCs/COECs. Could be used to remove suspended sediment from storm water, but simple retention basins are as effective (see Section A.3.4.1 above).

  Implementability: High. Readily implementable as part of an overall treatment system

  Cost: Moderate capital, moderate O&M.

  Site-Specific Considerations: Separation would not likely be sufficient as a standalone treatment technology because a large portion of the surface water COCs/COECs are in the dissolved phase.

  Potentially Applicable Areas: If used as a component of an overall treatment system, separation would be applicable to all Site surface water that requires treatment.

  Decision Rationale: Solid/water separation is not retained as standalone treatment because a large portion of the surface water COCs/COECs are in the dissolved phase, but retained for possible use in conjunction with other treatment options.

  Retained?: Yes – in conjunction with other treatment technology

- **Filtration.** Filtration is an effective technology for removing a wide particle-size range of suspended solids from surface water, but would not be a sufficient standalone technology to remove the dissolved COCs/COECs. While filtration alone would not be effective in treatment of surface water, it may be potentially applicable in conjunction with other treatment technologies, such as chemical precipitation or adsorption. Evaluation of this option against the three screening criteria and additional Site considerations is presented below.

Effectiveness: High if used in conjunction with other treatment technologies that precipitate dissolved COCs/COECs.

Implementability: High. Readily implementable as part of an overall treatment system.

Cost: Moderate capital, moderate O&M.

Site-Specific Considerations: Filtration is not sufficient as a standalone treatment technology because a large portion of the surface water COCs/COECs are in the dissolved phase.

Potentially Applicable Areas: If used as a component of an overall treatment system, filtration would be applicable to all Site surface water that requires treatment.

Decision Rationale: Filtration is not retained as standalone treatment because a large portion of the surface water COCs/COECs are in the dissolved phase. However, filtration could be used in conjunction with other treatment options.

Retained?: Yes – in conjunction with other treatment technology

- **Adsorption**. Adsorption with activated alumina (AA) is identified as a BAT for selenium water treatment technology (USBR, 2009a). Adsorption would be useful when combined with other treatment technologies for possible necessary reduction of metals to meet MCLs. Evaluation of this option against the three screening criteria and additional Site considerations is presented below.

  Effectiveness: High for select COCs/COECs. Adsorption with AA would be effective for selenium removal from surface water. However, pretreatment to reduce selenate (Se^{+6}) to selenite (Se^{+4}) would be required to increase effectiveness. Adsorption with AA is also a BAT for arsenic (USBR, 2010a). If arsenic occurs as As^{3+} oxidation would be required. However, when arsenic sources are blended together, this constituent would not likely occur at a concentration requiring treatment. Adsorption to granular activated carbon (GAC) is a BAT for cadmium (USBR, 2009b). Therefore, effective removal of selenium, arsenic and cadmium treatment could occur in multiple stages. The best application of adsorption may be as a polishing stage.

Implementability: High. Adsorption is readily implementable. To address all the COCs/COECs, the treatment train may be complex with multiple types of sorption media and upfront chemical reduction. In addition, it will generate a hazardous waste stream. A surge pond or ponds would probably have to be constructed to manage storm event and snowmelt runoff.

Cost: Moderate to high capital, high O&M.

Site-Specific Considerations: The treatment train may be complex with multiple types of sorption media and upfront chemical reduction to address all the Site COCs/COECs. For adsorption, other ions in the influent will have an effect on treatment efficiency and will need to be evaluated during treatability testing. The technology is adaptable to most Site flows to be treated, but may be more applicable to lower flow rates.

Potentially Applicable Areas: All areas where surface water is collected and requires treatment for disposal.

Decision Rationale: Not retained as a standalone treatment because most of the other technologies considered will likely provide the required level of treatment, and because sorption generates a hazardous waste stream. However, adsorption could be useful as a polishing step when combined with other treatment technologies for reduction of residual, dissolved COCs/COECs to meet ARARs (e.g., cadmium).

Retained?: No.

- **Ion Exchange.** While ion exchange may be applicable to treating contaminants in the Site surface water, it generates a brine stream from the regeneration and rinsing of the resins. Depending on the type and form of ion exchange resin used, the volume of the brine stream may be very small because the raw water COC/COEC concentrations are relatively low. The brine stream may require additional treatment prior to disposal or blending with the process effluent. Furthermore, ion exchange may be more expensive than other equally effective and implementable ex-situ treatment options. Evaluation of this option against the three screening criteria and additional Site considerations is presented below.

  Effectiveness: High. Ion exchange can be effective for all of the Site COCs/COECs. Different media may be required for different COCs/COECs (anionic vs. cationic).

Implementability: Moderate to High. Ion exchange is readily implementable, but usually results in generation of a liquid brine waste stream. A surge pond or ponds would probably have to be constructed to manage storm event and snowmelt runoff.

Cost: Moderate to high capital, moderate to high O&M.

Site-Specific Considerations: The elevated concentrations of arsenic, selenium, and cadmium in the Site surface water is the primary consideration. The technology is adaptable to most Site flow rates to be treated, but may be more applicable to lower flow rates. For ion exchange, other ions in the influent will have an effect on treatment efficiently and will need to be evaluated during treatability testing.

Potentially Applicable Areas: All areas where surface water is collected and requires treatment for disposal.

Decision Rationale: Ion exchange is not retained because of, in part, the brine stream from this process would require additional treatment. Moreover, ion exchange is more expensive than equally effective and implementable ex-situ water treatment technologies. An application of multiple resins could be effective for all of the COCs/COECs. Membrane technologies that are discussed below provide a higher and more reliable level of treatment for the COCs/COECs and many other constituents.

Retained?: No.

- **Membrane Technologies**. Membrane technologies include reverse osmosis (RO), nanofiltration (NF) and electrodialysis/electrodialysis reversal (ED/EDR). While these technologies are all effective at removing the COCs/COECs from Site surface water, they will produce a brine stream that likely would require further treatment prior to disposal. In some cases this brine stream can be treated and blended back into the treated RO stream. In addition, the processes have varying pretreatment requirements and high energy demand requirements. Evaluation of this option against the three screening criteria and additional Site considerations is presented below.

  Effectiveness: High. All technologies in this group are effective for removing COCs/COECs down to discharge standards. This technology is a USEPA BAT for selenium, arsenic, and cadmium.

Implementability: High. All technologies in this group are readily implementable. Membrane technologies have high electrical power requirements to pressurize the feed stream or to charge the membranes and produce an additional waste stream that would require treatment. A surge pond or ponds would probably have to be constructed to manage storm event and snowmelt runoff.

Cost: High capital, high O&M.

Site-Specific Considerations: Membrane technology is adaptable to the anticipated flow volumes to be treated. Membrane technology also is suitable to treat all ions in the Site groundwater.

Potentially Applicable Areas: All areas where surface water is collected and requires treatment for disposal.

Decision Rationale: Membrane technologies are retained because they are highly effective for treating all of the Site COCs/COECs. However, the brine stream from this process would require additional treatment or management.

Retained?: Yes.

B.3.6.2 Chemical

- **Chemical Precipitation**. Assuming the combination of appropriate treatment involving the use of chemical reagents (e.g., $FeCl_3$ or $Ca(OH)_2$) and separation/filtration, chemical precipitation would be capable of reducing concentrations of Site COCs/COECs to below surface water quality standards. In addition, chemical precipitation has a relatively low cost when compared to other ex-situ treatments/technologies. Important to note is that the oxidation state of selenium and arsenic influence the treatment efficiency. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

  Effectiveness: High. Chemical precipitation technology is effective for reducing most of the Site surface water COCs/COECs to meet the water quality standards. The technology is USEPA BAT for cadmium, selenium and arsenic (lime softening). However, chemical precipitation generates a sludge that requires management and disposal.

Implementability: High. Chemical precipitation is a common treatment process that is straightforward to implement for a wide range of flows. A surge pond or ponds would probably have to be constructed to manage storm event and snowmelt runoff.

Cost: Moderate capital, high O&M.

Site-Specific Considerations: Because selenium in surface water at the Site is selenate, it may be necessary to electrochemically reduce the influent surface water to produce selenite for improved selenium removal efficiency in the chemical precipitation process.

Potentially Applicable Areas: All areas where surface water is collected and requires treatment for disposal.

Decision Rationale: Chemical precipitation is retained as a treatment technology for removal of metals and/or selenium. Likely would require other ex-situ process options including reduction for selenium (discussed below) and separation/filtration to complete the treatment train, depending on the discharge requirements.

Retained?: Yes.

- **Oxidation/Reduction**. Oxidation/reduction is considered in conjunction with other technologies, such as chemical precipitation, when the oxidation state of the constituents being treated need to be altered. For example, because selenium in surface water at the Site is selenate, it may be necessary to electrochemically reduce the influent surface water to produce selenite. This change in oxidation state to selenite will improve selenium removal efficiency in the chemical precipitation process. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

  Effectiveness: High when considered in conjunction with other technologies such as chemical precipitation, which may require an oxidation/reduction step to change the oxidation state of the constituents being treated (e.g., selenate to selenite) to improve treatment efficiency.

  Implementability: High. Implementable for most Site COCs/COECs.

  Cost: Moderate capital, high O&M.

Site-Specific Considerations: Because selenium in surface water at the Site is selenate, it may be necessary to electrochemically reduce the influent surface water to produce selenite for improved selenium removal efficiency in the chemical precipitation process.

Potentially Applicable Areas: All areas where surface water is collected and requires treatment for disposal.

Decision Rationale: Not retained as a standalone treatment because it would not by itself reduce COC concentrations sufficiently. However, oxidation/reduction is retained as a treatment step (component) because it may be necessary to reduce selenate to selenite in influent surface water for improved selenium removal efficiency in the chemical precipitation process.

Retained?: Yes – in conjunction with other treatment technology

B.3.6.3 Thermal

- **Thermal Evaporation/Distillation**. Thermal evaporation/distillation is a very effective treatment technology, but also has very high capital and O&M costs compared to other effective treatment technologies. In addition, it may require construction of equalization basins to store water prior to treatment. Therefore, evaporation has been eliminated from further consideration. Evaluation of this option against the three screening criteria and additional Site considerations is presented below.

  Effectiveness: High. Thermal evaporation/distillation technology is highly effective for separating dissolved metals and inorganics from the process stream, essentially producing distilled water.

  Implementability: Moderate. Implementation of this technology for large quantities of collected surface water would likely require construction of an equalization pond for water storage.

  Cost: Very high capital, high O&M.

  Site-Specific Considerations: The technology is best suited to lower flows, and may not be suited to treatment during the spring runoff unless an equalization basin is used to store water prior to treatment. For thermal evaporation/distillation, the concentrations of all ions in the Site groundwater would be reduced.

Potentially Applicable Areas: All areas where surface water is collected and requires treatment for disposal.

Decision Rationale: Thermal evaporation/distillation is not retained due to very high capital and O&M costs compared to other equally effective technologies.

Retained?: No.

B.3.6.4 Biological

Ex-situ biological treatment involves the transformation, degradation or fixation of contaminants by microorganism activity in a constructed treatment cell or cells. The most common form of biological treatment for metals and some non-metals, like selenium, is biological reduction using anaerobic bacteria resulting in precipitation or sorption of the COC/COEC. This may be conducted in an anaerobic wetlands, a pond, or a bioreactor, as examples.

Bioreactor treatment can range from simple field systems to more complex treatment plants. P4 tested a bioreactor system for the treatment of dump seep water at the Site with favorable results for selenium, arsenic, cadmium and several other metals that would be a concern if the discharge was routed to surface water (P4, 2011). The system test consistently produced effluent that had selenium concentrations below the groundwater MCL (0.05 mg/L), but would need modifications to consistently meet the surface water discharge standard limit of 0.005 mg/L.

The bioreactor system consists of a surface water collection system, cells or tanks filled with reaction media/substrate, a nutrient feed system, and a discharge system. The complexity of biological treatment systems ranges from anaerobic/aerobic wetlands or the P4 pilot bioreactor to sophisticated biomechanical processes (often proprietary) with rotating media, fluidized beds, and other enhancements. Evaluation of the biological option against the three screening criteria and additional Site considerations is presented below.

Effectiveness: High. Biological treatment is effective for reducing concentrations of arsenic, selenium and cadmium, as demonstrated in the P4 pilot test. Treating water from surface sources presents challenges because the flow, temperature, and water quality can have significant seasonal variability. To improve winter operation temperature, control in a building could be necessary. System effectiveness can be less reliable (more prone to upsets) in comparison to non-biological processes (i.e., chemical precipitation).

Implementability: High. This technology is implementable as demonstrated by the P4 pilot testing. The system would have to be scaled up for treating all surface water sources. A surge pond or ponds would probably have to be constructed to manage storm events and snowmelt runoff.

Cost: Low to moderate capital depending on flow rate and moderate O&M. O&M costs include periodic replacement of bioreactor media and nutrient addition.

Site-Specific Considerations: Winter temperatures can reduce treatment efficiency.

Potentially Applicable Areas: All areas where surface water is collected and requires treatment for disposal.

Decision Rationale: Ex-situ biological treatment is retained because the technology was demonstrated at the Ballard Site for lower flows.

Retained?: Yes.

B.3.7 In-Situ Treatment

Most in-situ treatment technologies are not applicable to surface water and were eliminated in Section 4.3.4.6. Only biological treatment was retained.

B.3.7.1 Biological

In-situ biological treatment would consist of an option such as treatment wetlands (opposed to wetlands for containment discussed in Section A.3.4.2). The wetlands would be configured to contain anaerobic and aerobic components. For the treatment of seep or spring discharge, the wetlands can be configured directly atop of the discharge so that the water flows have minimal exposure to air, which increases the effectiveness of anaerobic functions. For runoff and storm water, the wetlands would have to be fed from a retention pond capable of storing the seasonal flow, then fed into the wetlands at a regulated rate. All of the COCs/COECs can sorb or precipitate in the anaerobic section of the wetlands. The aerobic portion of the wetlands would aerate the water, and the plant community can effect some additional polishing of the water. The wetlands system primarily functions in natural subsurface (anaerobic) environment and has some winter durability. The biological processes in the wetlands systems are less active and regulated compared to the more mechanical ex-situ system discussed in the previous section. The system can be more adaptable, but also less reliable than chemical/mechanical based systems. Evaluation of the in-situ biological option against the three screening criteria and additional Site considerations is presented below.

Effectiveness: Moderate, for seep and spring treatment. Effectiveness has not been demonstrated for Site surface waters. However, wetlands treatment is recognized to be effective for the Site COCs/COECs. A biological anaerobic/aerobic wetlands system is best suited to seep or spring discharge. However, naturally based treatment systems have some inherent reliability issues. Therefore, for treatment of seep and spring discharge, the technology is considered to have moderate effectiveness. For runoff and storm water, the effectiveness is lower and is unlikely to be used for this application.

Implementability: High. Wetlands are easily constructed.

Cost: Low to moderate capital depending on flow rate with low O&M.

Site-Specific Considerations: Winter temperatures can reduce treatment efficiency. Adding wetlands may be considered an ecological enhancement to the Site.

Potentially Applicable Areas: Site seeps and springs.

Decision Rationale: In-situ biological treatment is retained because a passive treatment technology could be suitable for residual seep and spring treatment following source controls (e.g., waste rock capping).

Retained?: Yes.

B.4 TECHNOLOGY SCREENING FOR SEDIMENT/RIPARIAN SOIL

In this section, the retained technologies and process options that were preliminarily screened in Section 4.4 are further screened against the effectiveness, implementability, and cost criteria. The rationale for retaining or eliminating each technology is presented below and summarized in **Table 5-3**.

B.4.1 No-Action

The No-Action option is always carried forward as a baseline case in the FS process and is required by the NCP, as discussed in the EPA RI/FS Guidance. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

Effectiveness: Low. The No-Action alternative is not effective for constituents that drive unacceptable risk or exceed the TBC ARARs.

Implementability: High. The No-Action alternative is easy to implement.

Cost: Low (no additional) capital costs, no O&M costs.

Site-Specific Considerations. The No-Action alternative is not appropriate in the Site drainages where there are unacceptable risks.

Potentially Applicable Areas: The No-Action alternative is only applicable to areas of the Site that meet RAOs.

Decision Rationale: Evaluation of the No-Action alternative is required by the NCP as a point of comparison with other alternatives.

Retained?: Yes. Although the No-Action alternative does not reduce risks or meet chemical-specific TBC ARARs in the Site sediment/riparian soil, it is retained as point of comparison as required by the NCP.

B4.2 Limited Action Response

The Limited Action Responses applicable to the Site sediment/riparian soil in the intermittent drainages include ICs and MNR.

B.4.2.1 Institutional Controls

Institutional Controls assist in achieving RAOs by: 1) limiting land or resource use/access, and 2) providing information that helps modify or guide human behavior at locations and in areas where COC concentrations prevent unlimited use and unrestricted exposure. ICs also are used to prevent exposures during the period between when an active remedy is implemented and the cleanup levels are achieved. The ICs that are applicable to the impacted intermittent drainages at the Ballard Site include proprietary controls and fencing.

- **Proprietary Controls**. Deed restrictions such as easements and restrictive covenants are the most applicable type of non-engineered ICs to restrict certain activities because much of the property that includes the impacted intermittent drainages is privately owned (see **Drawing 1-2**). The deed restrictions would include restrictions on the harvesting of culturally significant plants in the impacted drainages, and/or restrictions on activities that would disturb an active remedy such as sediment traps/basins.

Effectiveness: Moderate. Deed restrictions would potentially be effective in preventing humans from harvesting culturally significant plants, and/or preventing activities that would disturb an active remedy such as sediment traps/basins. However, deed restrictions may be difficult to enforce, do not prevent exposure or minimize risks to ecological receptors, and do not reduce the toxicity, mobility, or volume of the COCs.

Implementability: High. Deed restrictions are relatively easy to implement, but would require the cooperation of the private landowners.

Cost: Low capital; Low O&M. Costs include planning, legal support, and 5-year-review documentation.

Site-Specific Considerations. There are no Site-specific considerations that would inhibit establishing proprietary controls other than obtaining the cooperation of the private landowners.

Potentially Applicable Areas: Deed restrictions could be applicable to the entire reach of the impacted intermittent drainages.

Decision Rationale: Deed restrictions are retained because they may be the most feasible option to reduce human health risks along the entire reach of the impacted intermittent drainages, and because some form of ICs likely will be a component of the assembled remedy.

Retained?: Yes.

- **Fencing**. Fencing can be erected as an engineered control to prevent human and large-animal access to areas that have unacceptable risks. By limiting access to specific areas, fencing contributes to a reduction of risk by reducing the potential for exposure through direct contact with COCs/COECs. However, it does not reduce the toxicity, mobility, or volume of the COCs/COECs.

  Effectiveness: Moderate. Fencing is a land use control that potentially would be effective in preventing humans from harvesting culturally significant plants, and/or preventing activities that would disturb an active remedy such as sediment traps/basins. Although fencing may prevent access to large animals like elk or deer, it will not prevent access to smaller burrowing animals, birds, or aquatic species. Fencing does not reduce the toxicity, mobility, or volume of the COCs/COECs.

Implementability: High. Design and construction of perimeter fencing would be easy to implement.

Cost: Low capital; Low O&M. Costs include design, construction, periodic inspections/O&M, and 5-year-review documentation.

Site-Specific Considerations. Site-specific considerations for constructing a fence include obtaining the cooperation of the affected private landowners, and the perceived aesthetic impacts of a fence.

Potentially Applicable Areas: Fencing could be applicable to the entire reach of the impacted intermittent drainages.

Decision Rationale: Fencing is retained because it may be a feasible option to reduce human health risks in the intermittent drainages, and could be a component of the assembled remedy.

Retained?: Yes.

B.4.2.2 Monitored Natural Recovery

MNR is an EPA-recognized limited action response or remedy for contaminated sediment that typically uses ongoing, naturally occurring processes to contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediment (EPA, 2005). MNR also is being considered in this FS as a remedy for the riparian soil in the intermittent drainages for the reasons discussed in Section 4.4 (e.g., media is adjacent and contiguous, similar COCs/COECs, similar risks to culturally significant plants). In addition, MNR (as well as the other sediment technologies) rely on source controls for the upland soil and waste rock to remove the source of upstream loading of contaminants.

These processes may include physical, biological, and chemical mechanisms that act together to reduce the risk posed by the contaminants. Depending on the contaminants and the environment, this risk reduction may occur in a number of different ways including:

- Contaminant is converted to a less toxic form through transformation processes, such as biodegradation or abiotic transformations.
- Contaminant mobility and bioavailability are reduced through sorption or other processes binding contaminants to the sediment matrix.
- Exposure levels are reduced by a decrease in contaminant concentrations in the near-surface sediment zone through burial or mixing-in-place with cleaner sediment.

- Exposure levels are reduced by a decrease in contaminant concentrations in the near-surface sediment zone through dispersion of particle-bound contaminants or diffusive or advective transport of contaminants to the water column.

MNR is similar in some ways to the MNA remedy used for groundwater. The key difference between MNA for groundwater and MNR for sediment is in the type of processes most often being relied upon to reduce risk. Transformation of contaminants is usually the major attenuating process for contaminated groundwater, and these processes are frequently too slow for the persistent COCs/COECs in sediment/riparian soil (e.g., metals) to provide for remediation in a reasonable time frame. In the case of MNR, isolation and mixing of contaminants through natural sedimentation is the most frequently relied upon recovery process.

Natural processes that reduce toxicity through transformation or reduce bioavailability through increased sorption are usually preferable as a basis for remedy selection to mechanisms that reduce exposure through natural burial or mixing-in-place because the destructive/sorptive mechanisms generally have a higher degree of permanence. However, many contaminants that remain in sediment are not easily transformed or destroyed. For this reason, risk reduction due to natural burial through sedimentation is more common and can be an acceptable sediment management option. However, natural burial is more applicable to depositional environments such as lagoons as opposed to the intermittent stream channels at the Site that are prone to episodic flows that act to both erode and deposit sediments. Moreover, while natural burial may reduce contaminant uptake to aquatic organisms and plants, it may not prevent contaminant uptake to other culturally significant plants that have deeper root systems.

EPA considers dispersion to be the least preferable basis for remedy selection based on MNR because it may result in unacceptable risks to downstream areas or other receiving water bodies (EPA, 2005). However, when coupled with source control in the Site's upland soil, the dispersion mechanism may be considered acceptable, particularly because COC/COEC concentrations in the Blackfoot River (i.e., the receiving water body) are generally low in the current (pre-remedial action) Site configuration where up-gradient sources of COCs/COECs are not controlled.

Effectiveness: High. Following source control in the upland soil/waste rock, MNR would effectively reduce COC/COEC concentrations in the intermittent drainages that lead away from the mined area given sufficient time for the natural recovery processes to occur.

Implementability: High. MNR is non-invasive and relatively easy to implement, but would need long-term ICs to make it viable.

Cost: Low capital; Low O&M. Implementability costs are low and include some type of long-term monitoring, data interpretation, and reporting (typically at the CERCLA 5-year review). The additional costs related to Site characterization and modeling, if necessary, could raise the costs for MNR to moderate.

Site-Specific Considerations: Limited Site-specific data are available to understand the dominant MNR processes (e.g., rates of sedimentation and erosion), and to establish a remedial timeframe.

Potentially Applicable Areas: MNR could be applicable to the entire reach of the impacted intermittent drainages. Alternatively, MNR could be paired with other remedial technologies where an active technology (e.g., removal and on-Site disposal) is implemented in the more highly contaminated reaches near the waste rock piles and MNR is implemented in the lesser-contaminated lower reaches of the intermittent drainages.

Decision Rationale: MNR may be a feasible option to reduce both human health and ecological risks with no man-made physical disruption in the intermittent drainages; and could be a component of the selected Site remedy. Because the majority of the Site drainages are under P4 control and will be for the foreseeable future, human exposures to these areas are limited, and both human and ecological risks could be mitigated over time by MNR processes.

Retained?: Yes.

B.4.3 Removal and On-Site Disposal

B.4.3.1 Removal and On-Site Disposal

Contaminated sediment/riparian soil (and all associated vegetation) would be removed (excavated) and consolidated with the upland soil/waste rock; and subsequently remediated along with the upland soil/waste rock. The stream channels would be restored by re-contouring and re-vegetating the excavated areas. Best management practices would be employed during the excavation and stream restoration activities to:

- Restore stream geometry, vegetation, and habitat
- Minimize sediment mobilization

- Control erosion and sediment mobilization
- Stabilize and rehabilitate riparian areas
- Avoid contaminant spills (e.g., excavation equipment fuel and hydraulic fluids)

Effectiveness: High. The risk to sediment/riparian soil with COC/COEC concentrations in excess of the cleanup levels would be eliminated once the material was excavated. Any contaminated vegetation also would be removed.

Implementability: Moderate to high. Implementation is relatively straightforward using conventional excavation equipment. Excavated materials would be consolidated and remediated concurrently with the upland soil/waste rock. Industry-standard sampling techniques would be used to verify that cleanup levels are achieved. However, the extent of elevated COCs/COECs in the riparian soil/sediments above the cleanup level is not known and as a result, overexcavation could cause a substantial change in the channel geometry which would make implementation more challenging.

Cost: Moderate to high capital; Low O&M.

Site-Specific Considerations: Site terrain is conducive to using conventional excavation equipment. Excavation activities should be conducted during the dry season to minimize impact to waterways, downstream sedimentation, and water quality. Where warranted, temporary stream diversions would be appropriate to minimize these impacts. Also, consolidating the excavated sediment/riparian soil with the upland soil/waste rock could be combined during the remedial action, and would add relatively insignificant volume to the upland soil/waste rock that requires remediation. However, it should be recognized that concentrations of COCs/COECs in the sediment/riparian soil are highest near the mining disturbed areas (i.e., the source areas) and decrease rapidly with distance away from the source. As a result, excavation as a remedial option likely would be limited to the more highly contaminated areas of the intermittent drainages near the mine site coupled with other non-invasive alternatives in the less contaminated downstream reaches.

Potentially Applicable Areas: Removal and on-Site disposal likely only would be considered for the most contaminated areas near the mine waste rock piles; and this material would be consolidated with the upland soil/waste rock during remediation.

Decision Rationale: Removal and on-Site disposal of contaminated sediment and riparian soil is retained for the most contaminated areas near the mine waste rock piles because it could be relatively easy to implement and would meet the RAOs assuming source controls are implemented in the upland soil/waste rock.

Retained?: Yes.

B.4.3.2 Sediment Traps/Basins

Sediment traps/basins are small impoundments constructed in the intermittent drainages that cause the flow to slow significantly, which allows a portion of the entrained sediment to settle out. The traps/basins are formed by excavating an area or by placing an earthen embankment across a low area or drainage swale. An outlet or spillway is often constructed using large stones or aggregate to slow the release of runoff (USEPA, 1992). Sediment traps typically are installed when the drainage area is 5 acres or less. For larger drainage areas, sediment basins would be required. Periodic inspection would be required during the rainy season and after large rainfall events. The accumulated sediment must be removed, typically before the volume has reached one-third of the original trap volume.

Sediment traps/basins can be used as a standalone technology or in conjunction with other technologies. For example, sediment traps/basins may be used in conjunction with conventional excavation to protect receiving streams from potentially impacted sediments that are mobilized by the excavation activities. Sediment traps/basins also may be combined in an alternative that includes MNR to capture potentially impacted sediments while natural recovery processes are occurring. Sediment traps/basins on their own would not reduce exposures to contaminated sediments upstream of the traps/basins; and therefore would need to be coupled with ICs.

Effectiveness: Moderate. Sediment traps/basins installed in the intermittent drainages would act to capture a portion of the contaminated sediments and prevent them from migrating downstream from the trap/basin. As discussed above, the traps/basins would require periodic inspection and maintenance to remove and properly dispose of the captured contaminated sediments. Sediment traps/basins rely on natural erosional processes to transport contaminated sediments from areas upstream of the trap/basin to the trap/basin where they can be captured. Therefore, the timeframe for sediment traps/basins to effectively reduce the volume of contaminated sediments is dependent on the natural erosional processes, which can occur slowly over relatively long periods and would likely be episodic in the intermittent drainages at the Site (e.g., during spring runoff or heavy rainfall). Sediment traps/basins would be most effective if coupled with source controls in the upland soil/waste rock, but also could be effective in preventing downstream migration of contaminated sediments in lieu of source controls.

The effectiveness of the sediment traps/basins also depends on the efficiency of the trap/basin itself. Sediment trap/basin efficiency is a function of the particle size, the surface area of the trap/basin, and the peak inflow rate (Smolen et al., 1988). Sediment traps/basins only remove large and medium sized particles. The average sediment traps/basins have an average total suspended solids removal rate of 60 percent (USEPA, 1993).

<u>Implementability</u>: High. Sediment traps/basins are easily implemented at the Site. The sediment traps/basins would require periodic maintenance to clear and dispose of the accumulated sediment to operate effectively. These likely would be most useful where there are clearly defined swales in the intermittent streams.

<u>Cost</u>: Low capital; Low O&M. Capital costs would be low to install these relatively small basins. O&M costs would be low to moderate depending on the seasonal flows through individual Site drainages and for permitting and operation of an on-Site disposal area.

<u>Site-Specific Considerations</u>: The relatively small size of the intermittent drainages (both stream flows and channel widths) is conducive to the construction, operation, and maintenance of sediment traps/basins. Sediment traps/basins would need to be coupled with ICs to prevent human exposures to contaminated sediment/riparian soil (and the affected culturally significant plants) within and upstream of the traps/basins. The long-term cost and complexity of operating an on-Site disposal facility for sediments removed from the traps could compromise the relative ease of implementation. It would be necessary to operate this disposal facility until the concentrations of the COCs/COECs in the sediments meet the cleanup levels.

<u>Potentially Applicable Areas</u>: Sediment traps/basins could be applicable to the entire reach of the impacted intermittent drainages. Alternately, sediment traps/basins could be located in the more highly contaminated upper reaches of the drainages to help accelerate MNR processes.

<u>Decision Rationale</u>: Sediment traps/basins are retained as a technology because they could speed achievement of the RAOs, particularly if coupled with other technologies (e.g., MNR and/or ICs).

<u>Retained?</u>: Yes.

B.4.4 In-Situ/Ex-Situ Treatment

The sole sediment/riparian soil treatment technology retained following the initial screening discussed in Section 4.4.4.4 is solidification/stabilization (S/S):

- Solidification refers to processes that encapsulate a waste to form a solid material and/or coat the waste with low-permeability materials to restrict contaminant migration by decreasing the surface area exposed to leaching. Solidification can be accomplished by mechanical processes or by a chemical reaction between a waste and binding (solidifying) reagents, such as cement, kiln dust, or lime/fly ash (USEPA, 2000).
- Stabilization refers to processes that involve chemical reactions that reduce the leachability of a waste. Stabilization chemically immobilizes hazardous materials or reduces their solubility through a chemical reaction. This process may or may not change the physical nature of the waste (USEPA, 2000).

S/S technologies may not be effective for some forms of metal contamination and pilot or treatability studies likely would be necessary to determine the most effective binders and stabilizers for the Site COCs/COECs. Due to the extensive list of constituents, it may be difficult to identify binders and stabilizers that can effectively immobilize them all.

S/S can be performed either in- or ex-situ. In-situ S/S is performed by mixing binders and stabilizers into the sediment/riparian soil with a disc plow or rotary mixer. Ex-situ S/S requires excavation of the contaminated sediment/riparian soil prior to mixing binders and stabilizers in a pug mill or drum mixer. The materials that are treated ex-situ are either replaced or disposed of off Site. However, off-Site disposal is not retained as a disposal option for contaminated or treated sediment/riparian soil because these materials can be easily consolidated and remediated along with the upland soil/waste rock at the Site. Both in-situ or ex-situ S/S would require a pilot-scale field study to determine the best application method, mixing technique, and the most effective binders and stabilizers. Both in-situ or ex-situ S/S would require some form of stream restoration to revegetate disturbed areas.

Effectiveness: Moderate. Pending positive results of a treatability study to determine the most effective binders and stabilizers for the list of COCs/COECs requiring treatment, S/S may be effective for reducing long-term on-site risks by immobilizing the COCs/COECs thereby reducing leachability and bioavailability of COCs/COECs in sediment/riparian soil.

In-Situ Implementability: Moderate. In-situ mixing of the amendments with the contaminated soil and sediment can be achieved using in-place mixing with a disc plow or rotary mixer for soil 12 to 24 inches below ground surface. It is more difficult for in-situ S/S to achieve complete mixing to treat the contaminated soil in-place when compared to ex-situ S/S.

In the areas containing large cobbles, boulders, or debris, implementation would be more difficult as these materials may interfere with the efficiency of the subsurface mixing. Depending on the amount of cobbles, boulders, and debris, implementation would be more costly since as removal of these materials would be required prior to in-situ S/S. In these limited areas, screening of materials followed by ex-situ S/S may be more effective.

In areas submerged or saturated with water, in-situ S/S may not be practical. However, if implementation was completed in late summer or fall when the intermittent streams were dry, a large portion of the impacted sediment/riparian soil could be treated by this method. Temporary diversion of flowing reaches is a technique commonly used to enable the implementation of in-situ S/S in submerged areas.

Ex-Situ Implementability: High. Ex-situ S/S can be easily applied to excavated sediment/riparian soil because methods are available to provide the vigorous mixing needed to combine the amendments with the contaminated media. Pre-treatment, screening and crushing, will be required prior to treatment for any areas where cobbles, boulders, and debris are present. Ex-situ S/S is generally more invasive and destructive to the riparian corridors and resident wildlife than in-situ S/S, and is more costly and energy intensive. Moreover, ex-situ S/S requires a portion of the site be used to implement the technology, including staging areas for treatment equipment and sediment/soil stockpiles. Ex-situ S/S also requires handling and disposal or replacement of the treated materials.

In-Situ Cost: High capital, low O&M. Less labor and energy intensive than ex-situ S/S since excavation, transport, and disposal/re-application of the treated material are not required. O&M requirements are limited to stream restoration to revegetate disturbed areas.

Ex-Situ Cost: Very high capital, low O&M. Ex-situ S/S is more labor and energy intensive than in-situ S/S due to excavation, transport, and disposal/replacement of the treated material. O&M requirements are limited to stream restoration to revegetate disturbed areas.

Site-Specific Considerations: Site terrain and nature of the sediment/riparian soil likely is conducive to both in-situ and ex-situ S/S. In-situ or excavation activities should be conducted during the dry season to minimize impact to waterways, downstream sedimentation, and water quality. Where warranted, temporary stream diversions would be more appropriate to minimize these impacts.

S/S is typically used to treat highly contaminated soil and/or to reduce the leachability of characteristically hazardous waste. COC/COEC concentrations in the Site sediment/riparian soil are relatively low compared with other sites where S/S has been used (USEPA, 2000 and 2009). Therefore, S/S likely is not a cost effective remedial strategy considering the relatively low COC/COEC concentrations in the sediment/riparian soil in the intermittent drainages at the Site.

Potentially Applicable Areas: In-Situ or ex-situ S/S likely only would be considered for the most contaminated areas near the mine waste rock piles.

Decision Rationale: S/S is an established and effective active remediation technology for contaminated sediment/soil. However, this technology is not retained because it does not provide any advantages over the removal/on-Site disposal technology. Specifically:

- S/S would not be more effective than removal/on-Site disposal in meeting the RAOs.
- S/S would require a treatability study and pilot test prior to implementation, whereas removal/on-Site disposal would not.
- The advantages of in-Situ S/S may be lost if boulders or debris is encountered, which would require additional handling (e.g., ex-Situ S/S or disposal).
- Ex-situ S/S includes a treatment step that may not be required if the excavated soils are ultimately consolidated with the upland soil/waste rock (i.e., the consolidated materials may not require treatment if they are capped or covered).
- S/S likely is not a cost effective remedial strategy considering the relatively low COC/COEC concentrations in the sediment/riparian soil in the intermittent drainages at the Site.

Retained?: No.

B.5 TECHNOLOGY SCREENING FOR GROUNDWATER

In this section, the retained technologies and process options that were preliminarily screened in Section 4.5 are further screened against the effectiveness, implementability, and cost criteria. The rationale for retaining or eliminating each technology is presented below and summarized in **Table 5-4**.

B.5.1 No-Action

The No-Action option is always carried forward as a baseline case in the FS process and is required by the NCP, as discussed in the *EPA RI/FS Guidance*. Evaluation of this option against the three screening criteria and additional Site considerations is presented below.

> Effectiveness: Low. The No-Action alternative is not effective for constituents that drive unacceptable risk or exceed chemical-specific ARARs.
>
> Implementability: High. The No-Action alternative is easy to implement.
>
> Cost: Low (no additional) capital costs, no O&M costs.
>
> Site-Specific Considerations. The No-Action alternative is not appropriate where COCs concentrations exceed the groundwater ARARs.
>
> Potentially Applicable Areas: The No-Action alternative is only applicable to areas of the Ballard Site that meet the RAOs.
>
> Decision Rationale: Always retained in FS as a base case and may be used in areas that pose no risk. For groundwater, No Action would result in continued plume migration toward the Blackfoot River in the southwest portion of the Site. Alluvial plumes in other areas of the Site are not reaching surface water, and could be static because of natural attenuation. Future exposure due to small scale groundwater extraction could still occur. However, groundwater extraction of contaminated groundwater from this unit in the vicinity of the Site for beneficial use is unlikely, and not currently occurring.
>
> **Retained?**: Yes. Although the No-Action alternative does not reduce risks or meet chemical-specific ARARs in the Site groundwater, it is retained as point of comparison as required by the NCP.

B.5.2 Limited Action Response

Limited action responses applicable to the Site groundwater include ICs to limit groundwater use and monitored natural attenuation (MNA).

B.5.2.1 Institutional Controls

Institutional Controls assist in achieving RAOs by: 1) limiting land or resource use/access, and 2) providing information that helps modify or guide human behavior at locations and in areas where COC concentrations prevent unlimited use and unrestricted exposure. ICs also are used to prevent exposures during the period between when an active remedy is implemented and the cleanup levels are achieved. The ICs that are applicable to the impacted groundwater at the Ballard Site include governmental and proprietary controls to restrict groundwater use.

> Effectiveness: Moderate. ICs would potentially be effective in preventing groundwater extraction and use (e.g., consumption, irrigation). Would potentially limit exposure to groundwater COCs, but would not restrict COC migration to the Blackfoot River.
>
> Implementability: High. ICs to prevent groundwater use can be readily implemented on P4-owned portions of the Site (i.e., on much of the eastern half of the Site). On the western side of the Site (State and other private ownership) and affected areas east of the P4 property, ICs would require the cooperation of the landowners.
>
> Cost: Low. Costs include planning, legal support, and 5-year-review documentation.
>
> Site-Specific Considerations. There are no site-specific considerations that would inhibit establishing ICs other than obtaining the cooperation of the landowners.
>
> Potentially Applicable Areas: ICs could be applicable to all the areas where COC concentrations in groundwater exceed the ARARs.
>
> Decision Rationale: ICs are retained because they may be the most feasible option to reduce human health risks posed by groundwater, and because some form of ICs likely will be a component of the assembled remedy.
>
> **Retained?**: Yes.

B.5.2.2 Monitored Natural Attenuation

MNA is an EPA-recognized limited action response that relies on natural attenuation processes to meet the remediation goals for a Site. In the case of the inorganic COCs at the Site, the dominant attenuation process would be sorption to the aquifer matrix. USEPA presents the rationale and requirements for characterization and implementation in USEPA (1999, 2007a, and 2007b). In order for MNA to meet remediation goals in a realistic timeframe, source control needs to be a key component of the overall remedy. Moreover, long-term performance monitoring is a fundamental component of MNA in order to evaluate the natural attenuation processes and progress in meeting the objectives. MNA would require ICs to restrict groundwater use until ARARs are achieved, and more active remedies may be used in critical and high concentration portions of a groundwater plume (e.g., reactive barrier near a potential receptor). However, as a component of the overall Site remedy, MNA has the following advantages (USEPA, 1999):

- Contaminants remain in-situ reducing potential exposures
- The remedy is passive generating no secondary waste such as ex situ water treatment
- Can be broadly applied to groundwater plume across the Site
- Low surface disturbance, permitting and staffing requirement compared to active remedies
- Low cost

In some situations active treatment of the whole plume may be technically difficult or even impracticable. In such cases, MNA may provide an alternative method for achieving Site remediation.

The potential disadvantages include:

- Relatively long cleanup timeframes
- Additional site characterization may be required to support MNA
- Expanded Site monitoring program (extent and duration)
- Cross media transfer of COCs – sorption to the aquifer matrix
- Public acceptance of MNA may need expanded explanation and education
- May require a contingency or backup remedial plan

Key considerations regarding the suitability of MNA as a remedy include:

- Whether the contaminants are likely to be effectively addressed by natural attenuation processes
- The stability of the groundwater contaminant plume and its potential for migration
- The potential for unacceptable risks to human health or environmental resources by the contamination (considering potential use of contaminated groundwater, e.g., domestic supply or agricultural)

MNA should not be used where the remedy would result in either plume migration or impacts to environmental resources that would be unacceptable to the A/Ts. Therefore, MNA may be an appropriate candidate for a remedy if the contaminant plumes are no longer increasing in extent, or are shrinking (USEPA, 1999). These conditions are more likely met if source controls have been implemented.

Evaluation of this potential technology against the three screening criteria and additional Site considerations is presented below.

Effectiveness: Moderate. MNA effectiveness is based on Site-specific attenuation factors in the aquifer, some of which are not currently defined. Effectiveness also will be dependent upon the effectiveness of other remedies used in conjunction with MNA, such as the source controls. Plume migration at the Site is slow and in some cases near stagnant or stagnant (i.e., NW and NE areas), suggesting MNA would be effective in portions or all of the Site. The slow expansion of the plumes, and relatively static COC concentrations in monitoring wells, may indicate plume growth is already static due to attenuation processes.

Implementability: High. MNA is non-invasive and relatively easy to implement, but would need source controls and long-term ICs to make it viable. Implementation is dependent upon characterization and a technical assessment of practicability. In may require installation of additional monitoring wells to optimize monitoring well network.

Cost: Moderate capital, low O&M. (Capital cost include additional characterization and probable monitoring well installation.)

Site-Specific Considerations. Limited Site-specific data are available to understand the dominant MNA processes (e.g., sorption), and to establish a remedial timeframe.

Potentially Applicable Areas: MNA is potential applicable is all areas of groundwater contamination at the Site.

Decision Rationale: The natural attenuation effectiveness evaluation is dependent upon some additional data collection and evaluation (per USEPA, 2007a&b). However, given Site conditions, MNA should be considered a viable technology for portions of or whole groundwater COC plumes at the Site pending further evaluation.

Retained?: Yes.

B.5.3 Source Controls

Source controls are an effective way for reducing migration of COCs from source areas to groundwater by removing or containing the source of groundwater contamination. Source controls can include treatment of source areas through containment (capping), in-situ treatment and/or removal and ex-situ treatment. The technologies associated with source controls are discussed as part of the remedial technologies for upland soil/waste rock.

Effectiveness: The effectiveness of the remedial options discussed in Section B.2 that would result in source controls (i.e., cover systems, removal and on-Site disposal) are generally high. Effective source controls would reduce or eliminate COC migration to groundwater. However, source controls would not address COCs already in the vadose zone or groundwater. For these COCs, a separate remedy such as MNA may be required.

Implementability: Moderate to high. See **Table 5.1**.

Cost: Low to high capital, low to moderate O&M. See **Table 5.1**.

Site-Specific Considerations. See Section B.2.

Potentially Applicable Areas: See Section B.2.

Decision Rationale: Source controls in the upland soil/waste rock are likely to be a critical component of an overall groundwater remedy.

Retained?: Yes.

B.5.4 Containment

B.5.4.1 Vertical Barriers

Hydraulic barriers are formed through the addition or withdrawal of groundwater from the target aquifer or construction of a slurry or grout wall to limit or control groundwater movement. These measures contain the groundwater to limit receptor exposure. In some cases, these measures also can support groundwater extraction and treatment. Hydraulic barriers can consist of extraction wells, extraction trenches, injection wells, cutoff (slurry or grout) walls, or a combination of these. Injection wells and cutoff (slurry or grout) were eliminated from further consideration based on technical implementability discussed in Section 4.5.4.3.

- **Extraction Wells.** Extraction wells can be an effective technology to capture groundwater downgradient of source areas and to help prevent migration of groundwater that exceeds remediation goals. The use of extraction wells would require treatment and disposal of the extracted groundwater. There are two different hydrogeologic settings where extraction wells could be used at the Site. The first of these is the shallow alluvial groundwater unit that contains five plumes that originate from beneath the waste rock dumps. The second is the contaminated Wells Formation beneath and near the West Ballard Pit (MMP035). Evaluation of this option against the three screening criteria and additional Site considerations is presented below.

  <u>Effectiveness</u>: Can be effective for providing capture and hydraulic containment to minimize downgradient migration of impacted groundwater.

  <u>Effectiveness in the Alluvial Unit</u>: Moderate to high. The alluvial unit contains relatively thin (e.g., 1 inch to 2 feet), heterogeneous, alternating beds of higher permeability sands (some gravel) and lower permeability clay. The overall hydraulic conductivity of the alluvial unit is on the order of 10^{-4} cm/sec, but can be highly variable. Given the aquifer characteristics, shallow depths to groundwater, groundwater capture in the alluvial unit as a barrier could be effective with multiple wells. However, containment on the west side of the Site likely would require closely spaced wells along a perimeter of approximately 5,800 feet. On the east side, the impacted perimeter is about 2,000 feet long. Extraction wells also could be installed and operated upstream of where the southwest plume intersects the Blackfoot River. These wells would need to be spaced along a plume transect approximately 1,600 feet long. To be effective, extraction wells require overlapping capture zones, which may be

difficult to achieve in the variable and discontinuous bedding associated with the depositional setting of the alluvial unit.

Effectiveness in the Wells Formation: Low to moderate. The Wells Formation contains multiple relatively thick (5 to >20 feet) beds of sandstone that have hydraulic conductivities on the order of 10^{-3} to 10^{-2} cm/sec. These beds can produce significant groundwater, enough to supply industrial water for the area mines. However, the wells are deep and difficult to design and install because of loose fine sand in the units. Recovery of groundwater in select locations as a barrier could be effective, but due to the structurally complex nature of the Site geology, effectiveness may be low and/or difficult to demonstrate.

Implementability: Like effectiveness, implementability has to be considered in both hydrogeologic settings.

Implementability in the Alluvial Unit: Moderate. Extraction wells in the alluvial unit could be installed relatively easily using standard shallow well drilling and installation methods. However, in the alluvial aquifer, implementing an effective barrier would require closely spaced wells because of the low transmissivity of the unit resulting in relatively low to moderate yields and small capture zones. A complete barrier along the waste rock perimeter where selenium concentrations in groundwater exceed the MCL would be in excess of 7,000 feet, resulting in a large number of extraction wells and associated pumping, piping and control systems, performance monitoring wells, and O&M. It also would require treatment of groundwater prior to discharge or re-use. It may be more feasible to limit the extraction well locations to areas with favorable aquifer conditions or where COC concentrations are high (e.g., plume cores). In addition, barrier extraction wells may be favorable in areas where other technologies, like extraction trenches, are not implementable because of the depth of contaminated groundwater.

Implementability in the Wells Formation: Low. Extraction well installation in the Wells Formation is possible but difficult due to the complex hydrogeology and depth to groundwater. The wells typically would be several hundred feet deep and require special drilling methods because of the loose fine sand. The Wells Formation aquifer is also stratigraphically and structurally complicated, making effective well placement to install a barrier difficult. Locating the correct beds in the Wells Formation that contain COCs above cleanup criteria in multiple locations would be challenging and expensive.

Cost: High capital, high O&M.

Site-Specific Considerations: As discussed above, the hydrogeology and depth to contaminated groundwater in the alluvial unit and Wells Formation are key considerations for the extraction well technology.

Potentially Applicable Areas: Extraction wells are applicable to all areas where the ARARs are exceeded in the alluvial unit and Wells Formation groundwater. However, it may be more feasible to limit the technology to areas where the hydrogeology is more conducive to groundwater extraction and hydraulic containment.

Decision Rationale: Installing and operating extraction wells to form a complete hydraulic barrier for all alluvial plumes would be difficult to implement, may not be effective given the complexity of the aquifers, and would be high cost. A trench system would be a more functional and appropriate technology for a large scale containment system (discussed below). However, an extraction well system could be moderately effective and implementable as a barrier for selected areas in the alluvial unit, especially where the depth to groundwater or depth to the bottom of COC contamination may be beyond the reach of a trench system. Groundwater extraction as a barrier in the alluvial unit is therefore retained on a limited basis.

Although recovery of some of the contaminated Wells Formation groundwater is implementable, the effectiveness of this technology as a barrier is low to moderate and may be difficult to demonstrate. The cost for extraction and monitoring wells would be very high, along with the cost of managing and treating a large volume of extracted groundwater. As a result, the extraction well technology is rejected as a barrier in the Wells Formation.

Retained?: Yes – (for select areas in the alluvial unit); No – (in the Wells Formation)

- **Extraction Trenches.** Extraction trenches are typically constructed perpendicular to the direction of plume migration. They are backfilled with a highly permeable drain material, piping, and pumping systems to withdrawal groundwater that flows into the trench.

Alluvial Unit Effectiveness: High. For the shallow alluvial plumes extraction trenches can be more effective than an interceptor well system described above because of shallow depth to groundwater, and the relatively thin bedding and low permeability of the unit. Only in areas where contamination extends below the practical depth of trench excavation (e.g., 35 feet) would the effectiveness be low. Effectiveness is best if the trench can be keyed into low permeability units at the base of the trench. For the alluvial unit, it may be possible to key the trench into low permeability clay units.

Wells Formation Effectiveness: Low. It would be difficult or impossible to install a trench deep enough to intercept the contaminated groundwater in the Wells Formation.

Alluvial Unit Implementability: High. Implementability depends on soil conditions and depth. Based on current Site knowledge, several locations with substantial COC concentrations are favorable for trench recovery. For example, the east side of the Site were bedrock is shallow (e.g., 20 feet) allowing the trench to be keyed into a lower permeability unit, and there is an upward groundwater hydraulic gradient. The southwest side of the Site has shallow groundwater and narrow plumes near the source and near the Blackfoot River. Implementability along the west to northwest side of the Site is less certain.

Wells Formation Implementability: Low. A trench system for the Wells Formation is impracticable due to the depth of contaminated groundwater.

Cost: Moderate (alluvial unit) to high (Wells Formation) capital, moderate O&M.

Site Specific Considerations. As discussed above, the depth to contaminated groundwater is a key consideration for the extraction trench technology. The depth to contaminated groundwater in the alluvial unit is generally within the depth that extraction trenches can feasibly be excavated. It would be difficult or impossible to install a trench deep enough to intercept the contaminated groundwater in the Wells Formation.

Decision Rationale: Extraction trenches could be effective for intercepting shallow alluvial plumes. Installation could be relatively shallow and easy to implement in some areas. In other areas, depth to groundwater may be an impediment. The trenches would need to be coupled with treatment and disposal options. It would be difficult or impossible to install a trench deep enough to intercept the contaminated groundwater in the Wells Formation.

Retained?: Yes - alluvial unit; No - Wells Formation.

B.5.5 Removal and Disposal

Removal is considered the complete extraction of all contaminated groundwater and then disposal. This is different from containment, which only restricts contaminated groundwater movement. Different strategies for plume removal are discussed below.

B.5.5.1 Removal

- **Pumping.** A network of pumping wells could be installed to remove groundwater that contains elevated concentrations of COCs. This is similar to the extraction well system described as a vertical barrier above. However, the removal option assumes that the remedial goal includes reducing COC concentrations in groundwater to below cleanup levels, whereas the sole remedial objective for the vertical barrier is to prevent migration of contaminated groundwater. The network of pumping wells would require overlapping capture zones and the time to remediate the plume would be dependent upon the number and rate of flow toward the wells. In the alluvial unit, a removal system could consist of lines of recovery wells traversing the plume(s) or a grid of wells. Evaluation of this option against the three screening criteria and additional Site considerations is presented below.

  <u>Alluvial Unit Effectiveness:</u> Moderate. An effective system for capturing and decreasing mass of constituents in the alluvial groundwater plumes is considered possible. However, unless a large number of pumping wells are used, the time to achieve complete plume remediation would be relatively long, but faster than passive options (e.g., MNA). This is based on the transmissivity of the alluvial units, observed groundwater flow velocities, and plume sizes. Chemical mass desorbing from the aquifer matrix may also extend the cleanup timeframe.

  <u>Wells Formation Effectiveness:</u> Low to high. The effectiveness in the Wells Formation may be low to high because of the complex geologic setting. Demonstrating the effectiveness may also be difficult because of the complex hydrogeologic setting and difficult well installation conditions. However, because the source location in the mine waste is well known, extraction wells at that location could remove a significant mass of COCs for partial plume recovery and hydraulic containment. Portions of the plume away from the source area may not be recoverable because of excessive depth.

Alluvial Unit Implementability: Moderate. Pumping wells and performance monitoring wells could be installed using standard well drilling and installation technologies, but it would require installation of a large number groundwater extraction wells, a large network of pumping, piping, and control infrastructure, and associated O&M. It also would require treatment of groundwater prior to discharge or re-use.

Wells Formation Implementability: Low to moderate, particularly if partial plume capture is acceptable. Capture of a large portion of the plume may be implementable but difficult to demonstrate because of hydrogeological complexity and depth of the unit. The wells typically would be several hundred feet deep and require special drilling methods because of the loose fine sand. The Wells Formation aquifer is also stratigraphically and structurally complicated, making complete plume capture/removal difficult. However, a smaller number of pumping wells installed in plume cores (i.e., locations with high COC concentrations near source areas) could be moderately effective in removing the bulk of the contaminant mass in groundwater.

Cost: High capital, high O&M.

Site-Specific Considerations: The hydrogeology and depth to contaminated groundwater in the alluvial unit and Wells Formation are key considerations for the removal technology.

Potentially Applicable Areas: Extraction wells are applicable to all areas where the ARARs are exceeded in the alluvial unit and Wells Formation groundwater. In the Wells Formation, it may be more feasible to limit the technology to locations near the source area.

Decision Rationale: For the alluvial system, the technology would like have limited effectiveness or require a long remediation timeframe with high costs including ex-situ treatment. For plume remediation, in-situ treatment would be less expensive and have similar effectiveness. For the Wells Formation, it is one of the only practicable technologies for plume remediation even though the effectiveness could be low.

Retained?: No - alluvial unit; Yes - Wells Formation.

B.5.5.2 Disposal

- **Recycle/Reuse.** Following treatment, pumped groundwater could be used for dust suppression and/or irrigation. This option for disposal would be beneficial, as well as cost-effective when compared to other disposal options. However, the reuse options may not have the capacity for the volume of the groundwater that is recovered and treated. Evaluation of this option against the three screening criteria and additional Site considerations is presented below.

Effectiveness: Low. Although the treated water could be beneficially used (e.g., dust control, irrigation) the reuse options may not have the capacity for the volume of the groundwater that is recovered and treated. For example, the need for dust control water may not be sufficient to consume the produced water and would only last as long as remedial construction was occurring at the Site or possibly during mining at the neighboring Blackfoot Bridge Mine. Crops cultivated near the Site are not currently irrigated. It is possible that a local farmer could be plant a crop for which the irrigated water would be beneficial. Irrigation would only be an effective use of the groundwater during the growing season.

Implementability: Low because of the lack of a long-term, year-round use.

Cost: Low capital, low O&M. Requires pumping and piping to nearby fields for irrigation.

Site-Specific Considerations. A long-term, year-round use of the treated groundwater has not been identified.

Potentially Applicable Areas: Recycling/reuse would be applicable to all extracted groundwater.

Decision Rationale: Demand for water for reuse at the Site or Blackfoot Bridge Mine is likely not sufficient to consume the volume, nor is the demand for water for the Site reclamation or Blackfoot Bridge mining likely long enough duration to match the need for groundwater discharge. Likewise, crop irrigation is a seasonal demand and likely not sufficient to consume the volume of produced water

Retained?: No.

- **Land Application.** For land application, the recovered groundwater is applied to a land area by irrigation. The water is lost to evaporation (from sprays and on the ground) and transpiration from plants. A small fraction will infiltrate back to groundwater. COCs often will be fixated in the vegetation and soil so that the fraction that infiltrates back to the groundwater has reduced COC concentrations. The concept works best in arid to semi-arid areas where there is a significant depth to groundwater, thus ample COC attenuation potential. Some level of water treatment could be required to address cross media transfer of COCs, and potential percolation of COCs back to groundwater.

Effectiveness: Low to high depending on season. Land application could be an effective water disposal approach in the summer. Application in the winter would be hampered by freezing of the water distribution system, and water would likely freeze on and in the ground resulting in runoff. The pumped groundwater would have to be stored in a reservoir during the winter or only recovered seasonally for land application at the Site to work. However, for smaller volumes of recovered groundwater, land application could be effective.

Implementability: Low to moderate. Land application would require identification of a large tract of land with sufficient depth to groundwater (e.g., approximately 100 feet or more). Attenuation and cross-media transfer of COCs would have to be evaluated. An alternative for winter disposal would have to be developed such as storage.

Cost: Low capital, moderate O&M. Requires pumping and piping to nearby area for application. The need for a winter storage reservoir or additional water treatment and disposal during winter would increase costs.

Site-Specific Considerations: A large tract of land with sufficient depth to groundwater may not be available. Cross-media transfer of COCs to culturally significant plants could result in transfer of risks. Cold weather would complicate land application in the winter.

Potentially Applicable Areas: Land application could be applicable to all groundwater that is removed and treated.

Decision Rationale: May be a viable technology for disposal of small or seasonal volumes of water. Likely not applicable for large volumes of recovered groundwater. In addition, groundwater recovery rates would be relatively consistent throughout the year complicating disposal during the cold winter months. May be more applicable for seasonal mine waste rock seepage and runoff (addressed as surface water in Section 5.3).

Retained?: No.

- **Surface Water Discharge.** Pumped groundwater could be discharged to surface water utilizing a NPDES permit. The discharge would likely be to the existing Site surface water channels, which discharge to the Blackfoot River, or possibly to the Blackfoot Reservoir via pipeline. This is not an option for untreated groundwater with elevated selenium concentrations. The main stem of Blackfoot River from the confluence of Lanes and Diamond creeks to the Blackfoot Reservoir is a 303(d)-listed segment for selenium, sediment, dissolved oxygen, and elevated temperature (*RI Report* – MWH, 2014). As a result, if a NDPES permit could be issued, the permit limits are likely to be very stringent. Discharge of treated water to the Blackfoot Reservoir could provide more flexibility with less stringent permit limits. However, it is also noted that surface water standards for selenium are an order of magnitude lower than the groundwater standard, so infiltration back to groundwater is the least restrictive option.

Effectiveness: High providing an NPDES permit can be obtained.

Implementability: Low. Discharged groundwater would be a new discharge and would require a high level of treatment in order to meet NPDES requirements and public acceptance. Discharge to the Blackfoot Reservoir would require an approximately 10-mile-long pipeline, involve multiple land owners, and still may have low public acceptance.

Cost: Low to moderate capital for permitting, low O&M. Would be associated with a high treatment cost. (Note that this cost estimate does not include costs associated with treatment of the water prior to discharge.)

Site-Specific Considerations: Most Site surface water drainages flow to the Blackfoot River. The main stem of Blackfoot River from the confluence of Lanes and Diamond creeks to the Blackfoot Reservoir is a 303(d)-listed segment as noted above. Obtaining NPDES permits to drainages for a new discharge, which would add a new selenium load, could be difficult or overly stringent.

Potentially Applicable Areas: Could be applicable to all groundwater that is removed and treated.

Decision Rationale: Surface water discharge is not retained due to the anticipated stringent requirements to obtain an NPDES permit (for discharge to the Blackfoot River), and technical issues that direct discharge to the Blackfoot Reservoir would involve (long pipeline crossing property with varying ownership).

Retained?: No.

- **Evaporation/Infiltration Basin.** Discharge to an evaporation/infiltration basin would require some treatment of the groundwater before it is discharged. Infiltration to the alluvial unit could be difficult unless an area with relatively high permeability is identified. A basalt, which typically can have relatively high permeability because of fracturing, is present west of the Site in the valley and could be an option for a basin. Infiltration to the Wells Formation in the bottom of one of the mine pits would also be an option. Evaporation would only be seasonally effective. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

  <u>Effectiveness</u>: Moderate to high. Effective for disposal of treated water providing an area with sufficient permeability can be identified for infiltration. Evaporation would only be effective for water disposal during the warmer months. Infiltration into a permeable unit of the Wells Formation would be highly effective, as would infiltration into the basalt unit.

  <u>Implementability</u>: Moderate. An evaporation/infiltration basin would require pretreatment of groundwater prior to discharge. If infiltration to the Wells Formation is considered, use of one of the mine pits could be a readily available location (shallow injection wells could be an option in this setting). Infiltration to the alluvial system may be possible for a small volume of water if permeable beds can be located. For infiltration into the basalt, an agreement with an adjacent landowner would be required.

  <u>Cost</u>: Moderate capital, low O&M if applied on-Site. Capital cost increase if implemented off-Site. (Note that this cost estimate does not include costs associated with treatment of the water prior to discharge.)

  <u>Site-Specific Considerations</u>: Disposal of pumped and treated groundwater via an infiltration basin is dependent on identifying an area with suitable permeability. Disposal of pumped and treated groundwater via an evaporation basis would only be feasible during the warm summer months.

  <u>Potentially Applicable Areas</u>: Could be applicable to all groundwater that is removed and treated.

  <u>Decision Rationale</u>: Implementable on-Site and could be used for reintroducing clean groundwater into the aquifer, and has a low to moderate cost.

  <u>Retained?</u>: Yes.

B.5.6 Ex-Situ Treatment

A detailed description of the ex-situ treatment technologies that were retained following the initial screening described in Section 4.5.4.5 for the groundwater COCs at the Site is provided below. Prior to full-scale implementation, one or more of the technologies would need to be pilot-tested to determine the effectiveness to reduce COCs to acceptable levels. Three general categories of ex-situ treatment technologies for groundwater are evaluated below including physical, chemical, and thermal categories and their associated process options.

B.5.6.1 Physical

- **Solid/Water Separation.** Separation consists of mechanical and gravity methods for bulk removal of suspended solids from groundwater. Considering that most of the groundwater COCs are in the dissolved phase, separation would not be sufficient as a standalone technology, but could be incorporated as a component of a larger treatment system. For example, a clarifier is often a component of a chemical precipitation process to gravity separate the newly formed solid contaminants. Chemical processes such as lime softening and coagulation both generate large volumes of solids that need to be separated from the treated water stream.

  Effectiveness: High if used in conjunction with other treatment technologies that precipitate dissolved COCs.

  Implementability: High. Readily implementable as part of an overall treatment system.

  Cost: Moderate capital, moderate O&M.

  Site-Specific Considerations: Separation is not sufficient as a standalone treatment technology because most of the groundwater COCs are in the dissolved phase.

  Potentially Applicable Areas: If used as a component of an overall treatment system, separation would be applicable to all Site groundwater that requires treatment.

  Decision Rationale: Rejected as standalone treatment because it would not by itself reduce COC concentrations sufficiently, but retained for possible use in conjunction with other treatment options.

  Retained?: Yes – in conjunction with other technology

- **Filtration.** Filtration is an effective technology for removing a wide size range of suspended solids from groundwater, but would not be a sufficient standalone technology to remove the dissolved COCs. While filtration alone would not be effective in treatment of the groundwater, it may be potentially applicable in conjunction with other treatment technologies, such as chemical precipitation or adsorption. Evaluation of this option against the three screening criteria and additional Site considerations is presented below.

  Effectiveness: High if used in conjunction with other treatment technologies that precipitate dissolved COCs.

  Implementability: High. Readily implementable as part of an overall treatment system.

  Cost: Moderate capital, moderate O&M.

  Site-Specific Considerations: Separation is not sufficient as a standalone treatment technology because most of the groundwater COCs are in the dissolved phase.

  Potentially Applicable Areas: If used as a component of an overall treatment system, filtration would be applicable to all Site groundwater that requires treatment.

  Decision Rationale: Filtration is not retained as standalone treatment because most of the groundwater COCs are in the dissolved phase. However, filtration could be used in conjunction with other treatment options.

  Retained?: Yes – in conjunction with other technology

- **Adsorption.** Adsorption with AA is identified as a BAT for selenium water treatment, as is GAC for cadmium (USBR, 2009a). Adsorption would be useful when combined with other treatment technologies for possible additional reduction of metals to meet ARARs. Evaluation of this option against the three screening criteria and additional Site considerations is presented below.

  Effectiveness: High for select COCs. Adsorption with AA would be effective for selenium removal from groundwater. However, pretreatment to reduce selenate (Se^{+6}) to selenite (Se^{+4}) would be required to increase effectiveness. Adsorption to GAC is a BAT for cadmium (USBR, 2009b). Therefore, effective removal of selenium and cadmium treatment could occur in multiple stages. The best application of adsorption may be as a polishing stage in other treatment trains.

Implementability: High. Readily implementable. To address all the COCs, the treatment train may be complex with multiple types of sorption media and upfront chemical reduction. In addition, it will generate a hazardous waste stream.

Cost: Moderate to high capital, high O&M.

Site-Specific Considerations: The treatment train may be complex with multiple types of sorption media and upfront chemical reduction to address all the Site COCs/COECs. For adsorption, other ions in the influent will have an effect on treatment efficiency and will need to be evaluated during treatability testing. The technology is adaptable to most Site flows to be treated, but may be more applicable to lower flow rates.

Potentially Applicable Areas: All areas where groundwater is collected and requires treatment for disposal.

Decision Rationale: Not retained as a standalone treatment because most of the other technologies considered will likely provide the required level of treatment. However, adsorption could be useful as a polishing step when combined with other treatment technologies for reduction of residual, dissolved COCs to meet the ARARs (e.g., cadmium).

Retained?: No.

- **Ion Exchange.** While ion exchange may be applicable to treating contaminants in the Site groundwater, a negative aspect of this technology is that it generates a brine stream from the regeneration and rinsing of the resins. Depending on the type and form of ion exchange resin used, the volume of the brine stream may be very small because the raw water COC concentrations are relatively low. The brine stream may require additional treatment prior to disposal or blending with the process effluent. Furthermore, ion exchange may be more expensive than other equally effective and implementable ex-situ treatment options. Evaluation of this option against the three screening criteria and additional Site considerations is presented below.

  Effectiveness: Moderate to High. Ion exchange can be effective for all of the COCs. Different media may be required for different COCs (anionic vs. cations). Competing ions could reduce effectiveness (e.g., selenate and sulfate).

Implementability: High. Readily implementable, but usually results in generation of a liquid brine waste stream.

Cost: Moderate/high capital, moderate to high O&M.

Site-Specific Considerations: The elevated concentrations of arsenic, selenium, and cadmium in the Site groundwater is the primary consideration. The technology is adaptable to most Site flow rates to be treated, but may be more applicable to lower flow rates. For ion exchange, other ions in the influent will have an effect on treatment efficiency and will need to be evaluated during treatability testing.

Potentially Applicable Areas: All areas where groundwater is collected and requires treatment for disposal.

Decision Rationale: Ion exchange is not retained because the brine stream from this process would require additional treatment. Moreover, ion exchange is more expensive than equally effective and implementable ex-situ water treatment technologies. Membrane technologies that are discussed below provide a higher and more reliable level of treatment.

Retained?: No.

- **Membrane Technologies.** Membrane technologies include RO, NF and ED/EDR. While these technologies are all effective at removing the COCs from Site groundwater, they will produce a brine stream that likely would require further treatment prior to disposal. In some cases this brine stream can be treated and blended back into the treated RO stream. In addition, the processes have varying pretreatment requirements and high energy demand requirements. While similar, each technology in this group has unique performance aspects based on water types treated, discharge required, and brine reject quality and quantity. Selection of the specific membrane technology warrants an engineering study to optimize the selection. Evaluation of this option against the three screening criteria and additional Site considerations is presented below.

  Effectiveness: High. All technologies in this group are effective for removing COCs down to discharge standards. This technology is a USEPA BAT for selenium and cadmium.

  Implementability: High. All technologies in this group are readily implementable. Membrane technologies have high electrical power requirements to pressurize the feed stream or to charge the membranes and produces an additional waste stream that would require treatment.

<u>Cost</u>: High capital, high O&M.

<u>Site-Specific Considerations</u>: Membrane technology is adaptable to the anticipated flow volumes to be treated. Membrane technology also is suitable to treat all ions in the Site groundwater.

<u>Potentially Applicable Areas</u>: All areas where groundwater is collected and requires treatment for disposal.

<u>Decision Rationale</u>: Membrane technologies are retained because they are highly effective for treating all of the Site COCs. This is opposed to Ion Exchange and Absorption technologies that also produce waste streams, but are less effective for treating all the COCs. Membrane technologies can consistently produce water with very low COC concentrations. Options exist for further treating the brine and blending a portion back into the discharge. However, often the brine stream from this process requires additional management (disposal).

<u>Retained?</u>: Yes.

B.5.6.2 Chemical

- **Chemical Precipitation.** Assuming the combination of appropriate treatment involving the use of chemical reagents (e.g., $FeCl_3$ or $Ca(OH)_2$) and separation/filtration, chemical precipitation would be capable of reducing concentrations of site COCs below ARARs. In addition, chemical precipitation has a relatively low cost when compared to other ex-situ treatments/technologies. Important to note is that the oxidation state of selenium influences the treatment efficiency. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

  <u>Effectiveness</u>: High. Chemical precipitation is effective for reducing most of the Site COCs to meet ARARs. USEPA BAT for cadmium and selenium (lime softening). Generates a sludge that requires management and disposal. However, effectiveness for selenium requires successful reduction of Site selenate to selenite (the following technology), which can be difficult with sulfate present. Effectiveness is moderate to high.

Implementability: High. Chemical precipitation is a common treatment process that is straightforward to implement for a wide range of flows.

Cost: Moderate capital, high O&M.

Site-Specific Considerations: Because selenium in groundwater at the Site is selenate, it may be necessary to electrochemically reduce the influent groundwater to produce selenite for improved selenium removal efficiency in the chemical precipitation process.

Potentially Applicable Areas: All areas where groundwater is collected and requires treatment for disposal.

Decision Rationale: Chemical precipitation is retained as a treatment technology for removal of metals and/or selenium. Likely would require other ex-situ process options (e.g., separation/filtration and selenate reduction) to complete the treatment train, depending on the discharge requirements. Chemical precipitation generates a sludge that would require management and disposal (landfilling).

Retained?: Yes.

- **Oxidation/Reduction.** Oxidation/reduction is considered in conjunction with other technologies, such as chemical precipitation, when the oxidation state of the constituents being treated need to be altered. For example, because selenium in groundwater at the Site is selenate, it may be necessary to electrochemically reduce the influent groundwater to produce selenite. This change in oxidation state to selenite will improve selenium removal efficiency in the chemical precipitation process. Evaluation of this option against the three screening criteria and additional site considerations is presented below.

  Effectiveness: High when considered in conjunction with other technologies such as chemical precipitation, which may require an oxidation/reduction step to change the oxidation state of the constituents being treated (e.g., selenate to selenite) to improve treatment efficiency during chemical precipitation. Effectiveness can be affected by similar ions.

  Implementability: High. Implementable for most Site COCs.

  Cost: Moderate capital, high O&M.

Site-Specific Considerations: Because selenium in groundwater at the Site is selenate, it may be necessary to electrochemically reduce the influent groundwater to produce selenite for improved selenium removal efficiency in the chemical precipitation process.

Potentially Applicable Areas: All areas where groundwater is collected and requires treatment for disposal.

Decision Rationale: Not retained as a standalone treatment because it would not by itself reduce COC concentrations sufficiently. However, oxidation/reduction could be useful as a treatment step (component) because it may be necessary to reduce selenate in influent groundwater to selenite for improved selenium removal efficiency in the chemical precipitation process.

Retained?: Yes – in conjunction with other technology

B.5.6.3 Thermal

Thermal evaporation is a very effective treatment technology that can produce an effluent with significantly reduced concentrations of the Site COCs. However, the technology also has very high capital and O&M costs compared to membrane treatment technologies that produce a similar effluent quality. Evaluation of this option against the three screening criteria and additional Site considerations is presented below.

Effectiveness: High. Thermal evaporation/distillation technology is effective for separating dissolved metals and inorganics from the process stream, essentially producing distilled water.

Implementability: Moderate. Implementation of this technology for large quantities of extracted groundwater would likely require construction of an equalization pond for water storage.

Cost: Very high capital, high O&M.

Site-Specific Considerations: The technology is best suited to lower flows, and may not be suited to treatment at the Site if water is extracted from the Wells Formation because of possibly high discharge rates. For thermal evaporation/distillation, the concentrations of all ions in the Site groundwater would be reduced.

Potentially Applicable Areas: All areas where groundwater is collected and requires treatment for disposal.

Decision Rationale: Thermal evaporation/distillation is not retained due to very high capital and O&M costs compared to other equally effective technologies (e.g. membranes).

Retained?: No.

B.5.6.4 Biological

Ex-situ biological treatment involves the transformation, degradation or fixation of contaminants by microorganism activity in a constructed treatment cell or cells. The most common form of biological treatment for metals and some non-metals, like selenium, is biological reduction using anaerobic bacteria resulting in precipitation or sorption of the COC. This may be conducted in an anaerobic wetlands, a pond, or a bioreactor, as examples.

Bioreactor treatment can range from simple field systems to more complex treatment plants. P4 tested a bioreactor system for the treatment of dump seep water at the Site with favorable results for selenium, arsenic, cadmium and several other metals that would be a concern if the discharge was routed to surface water (P4, 2011). The system tested consistently produced effluent that had selenium concentrations below the groundwater MCL (0.05 mg/L), but would need modifications to consistently meet the surface water discharge standard limit of 0.005 mg/L. For infiltrating extracted and treated groundwater back to the groundwater, the level of treatment required would be the MCL or lower.

The bioreactor system consists of a groundwater collection system, cells or tanks filled with reaction media/substrate, a nutrient feed system, and a discharge system. The complexity of biological treatment systems ranges from anaerobic/aerobic wetlands or the P4 pilot bioreactor to sophisticated biomechanical processes (often proprietary) with rotating media, fluidized beds, and other enhancements. Evaluation of the biological option against the three screening criteria and additional Site considerations is presented below.

Effectiveness: High. Biological treatment is effective for reducing concentration of selenium and cadmium, as demonstrated in the P4 pilot test. Treating extracted groundwater in a biological treatment system has some advantages compared to treating water from surface sources because the flow, temperature, and water quality have less seasonal variation. Nonetheless, the effectiveness can decrease in the winter because of low ambient temperature. To improve winter operation, temperature control in a building could be necessary. System effectiveness can be less reliable (more prone to upsets) in comparison to non-biological processes (i.e., chemical precipitation).

Implementability: High. This technology is implementable as demonstrated by the P4 pilot testing. The system would have to be scaled up for treating extracted alluvial groundwater. The rate of groundwater withdrawal from the Wells Formation could require an excessively large treatment system.

Cost: Low to moderate capital depending on flow rate (alluvial and/or Wells Formation), moderate O&M. O&M costs include periodic replacement of bioreactor media and nutrient addition.

Site-Specific Considerations: High concentrations of sulfate can affect the efficiency of selenium treatment; however, this was shown not to be an issue during the P4 pilot testing of the technology. Winter temperatures can reduce treatment efficiency.

Potentially Applicable Areas: All areas where groundwater is collected and requires treatment for disposal.

Decision Rationale: Biological treatment is retained because the technology was demonstrated at the Ballard Site.

Retained?: Yes.

B.5.7 In-Situ Treatment

A detailed description of the in-situ treatment technologies that were retained following the initial screening described in Section 4.5.4.6 for the groundwater COCs is provided below. Prior to full-scale implementation, the technologies would need to be pilot tested to determine their effectiveness at reducing the levels of COCs to target cleanup levels. An evaluation of the chemical and biological in-situ treatment technologies considered for contaminated groundwater at the Site is provided below.

B.5.7.1 Chemical

- **Chemical Injection (reduction).** Injection of chemicals is most effective for altering the pH or redox conditions of groundwater and then precipitating COCs such as metals or resulting in the adsorption of the metals to the aquifer matrix (both of which can be reversible). These reactions can cause additional chemical reactions within the formation and may significantly reduce the permeability of the zone being treated. For the Site COCs, the reduction to less soluble species would be the focus of the most viable in-situ treatment methodologies (e.g. selenate to selenite to elemental selenium or selenide, which will precipitate). Injectable sulfur compounds are a technology used for facilitating reduction in an aquifer – for example calcium polysulfide or sodium hydrosulfite (dithionite) (TBEC, 2005). These chemicals are injected into the contaminated aquifer resulting in zones of dissolved COC removal. The technology can be used for barriers or for aggressive complete-aquifer remediation. The technology can be effective for the reducible Site groundwater COCs, selenium and cadmium. For the Site, grid pattern injections could be utilized in areas where COCs exceed the remediation goals. Bench and pilot testing would be needed to validate this technology for the Site.

The technology has many factors that would affect its usefulness, implementability and effectiveness. Evaluation of this option against the three screening criteria and additional Site considerations is presented below.

<u>Effectiveness</u>: The direct effectiveness on the Site COCs should be high, but would need to be demonstrated through bench and field pilot testing. The hydrogeology has pronounced effects on the effectiveness as discussed below for the two units.

<u>Effectiveness in Alluvial Unit</u>: Moderate to High. In-situ chemical treatment and remediation has been implemented at multiple sites in the U.S. (TBEG, 2005). It is considered an established treatment/remediation technology; however, the long-term effectiveness has not been evaluated. A limit to the effectiveness could be the heterogeneity of the alluvial unit. The alluvial unit can be accessed using direct-push injections or direct-push-installed wells, allowing for a high density of injections, and therefore, increasing the potential effectiveness (considered to be high, but would require testing).

<u>Effectiveness in the Wells Formation</u>: Low. Injections into the Wells Formation are not likely to be spaced closely and would rely on dispersion in the formation, which has complex hydrogeology. Therefore, the potential effectiveness in the Wells Formation is expected to be low.

Implementability in the Alluvial Unit: High. In situ chemical treatment consists of injection wells or direct-push injections, common equipment and components, and no challenges would be anticipated for the alluvial unit. The single exception may be the variable hydrogeologic character of the alluvial unit, which could result in variable and incomplete dispersion of injected chemicals.

Implementability in the Wells Formation: Low. For the Wells Formation, injection would have to be through a few relatively expensive injection wells. While feasible, predicting or monitoring dispersion in the unit would be very difficult because of the stratigraphic and structural complexity.

Cost: Alluvial unit - moderate capital, low O&M (for a one or two injections). Wells Formation - high capital, low O&M.

Site-Specific Considerations: The hydrogeological character of the groundwater systems are critical in determining the effectiveness and implementability of in-situ chemical treatment. The alluvial unit is shallow and unconsolidated and is therefore easy to treat with a large number of borings. The Wells Formation has to be accessed with deep bedrock drill holes, but has higher permeability and injected chemicals would have greater dispersion. The chemical composition of the groundwater (e.g., species present and competing ions) and aquifer matrix also will affect the effectiveness of the chemical treatment.

Potentially Applicable Areas: All areas of groundwater contamination, but may have limited effectiveness and implementability in the Wells Formation.

Decision Rationale: Chemical reduction is likely to be effective for remediating Site COCs in groundwater. However, effectiveness would need to be validated with testing. Implementation in the alluvial unit is straightforward, whereas, implementation in the Wells Formation is very complex and would be hard to demonstrate effectiveness. However, the cost of this alternative would not be associated with substantially reduced potential risk exposure compared to other alternatives. Time to complete plume remediation would be reduced compared to other technologies (e.g., barriers and MNA).

Retained?: Yes - Alluvial unit; No - Wells Formation.

- **Reactive Barriers.** Permeable reactive barriers (PRBs) and chemical-injected reductive reaction zones are both closely related technologies, and will be referred to here as PRBs.

These technologies are applied as a barrier to contaminated groundwater flow opposed to general plume treatment as discussed above. PRBs are potentially useful for treatment of metals and other inorganics in the Site groundwater. However, reactive barriers are limited by the depth to which they can be placed (maximum demonstrated depth is 45 feet), while injected zones can be constructed to greater depths (e.g., 100 feet). With deeper injected zones, predicting the dispersion of chemicals within the formation, which ultimately would determine the effectiveness of PRB treatment, can be difficult. There is also uncertainty regarding the long-term effectiveness of this technology. Chemicals such as calcium polysulfide or sodium hydrosulfite (dithionite) can be used as injections (discussed in the previous technology), but in a trench, zero-valent iron and organic matter are also options (TBEG, 2005). The specific treatment reagent for the PRBs would be determined through testing. Evaluation of this option against the three screening criteria and additional Site considerations is presented below.

Effectiveness: The long-term effectiveness would be dependent on a number of factors including ability to intercept the plume, thickness of the treatment zone, treatment reagent(s), and contaminant load. A PRB can be a long-term passive treatment system in some configurations, especially if a biological component is introduced, or can be active with regular chemical feeds with effectiveness determined by factors like plugging. Effectiveness in each of the units is presented below.

Effectiveness in the Alluvial Unit: Low to high. PRBs are effective for treatment of the Site COCs. In the shallow alluvial unit, PRBs should be effective near the sources, but could also be an effective treatment southwest of the Site where the groundwater plume intersects the Blackfoot River.

Effectiveness in the Wells Formation: Low. Effectiveness in the Wells Formation is likely to be low because of constructability issues (discussed below).

Implementability in the Alluvial Unit: High. In the alluvial aquifer, an effective barrier would require closely spaced borings, or more likely a backfilled trench. The relatively shallow depth-to-groundwater (approximately 1 to 10 feet) and shallow source (i.e., infiltration from waste rock above the native ground surface) are favorable for implementation. A complete PRB along the waste rock perimeter that exceeds the selenium ARAR (MCL) would be in excess of 7,000 feet. For a few restricted areas, small plumes, or plume cores, this may be more readily implementable. For example where the groundwater plume reduces in width on the southwestern corner of the Site (see **Drawing 2-8**).

Implementability in the Wells Formation: Low. In the Wells Formation, an injection well PBR is possible but difficult. The wells have to be several hundred feet deep and require special drilling methods because of the loose fine sand. The Wells Formation aquifer is also stratigraphically and structurally complicated, making effective well placement difficult. That is, locating the correct stratigraphic locations in the Wells Formation in multiple locations would be challenging and expensive.

Cost: Alluvial unit - Moderate capital, low O&M. Wells Formation - High capital, moderate O&M.

Site-Specific Considerations: The depth to Site groundwater is the most important consideration for implementability. The alluvial unit is shallow and unconsolidated, and it is therefore straightforward to constructed PRBs. The Wells Formation is a deep bedrock unit, making construction of a reactive barrier difficult having to rely on closely spaced wells and the dispersion of the reactive material within the aquifer.

Potentially Applicable Areas: All areas of groundwater contamination, but may have limited effectiveness and implementability in the Wells Formation.

Decision Rationale: PRBs have been used with some success to treat groundwater contaminated with inorganic COCs. Effectiveness and implementability in the alluvial unit is likely to be high. PRB implementation in the Wells Formation would have to be through deep borings, and therefore, implementation would be difficult and would likely result in low effectiveness.

Retained?: Yes - Alluvial unit; No - Wells Formation.

B.5.7.2 Biological

In-situ biological treatment of groundwater would involve injecting carbon, nutrients, and possibly bacteria into the aquifer. The application and treatment principles are similar to the ex-situ biological treatment and in-situ chemical treatment discussed previously. It consists of enhancing the biological transformation of COCs by microorganisms to less mobile species. In addition, biological treatment may naturally follow in-situ chemical treatment discussed above. That is, the chemical treatment may treat the bulk of the contaminant load, and as a by-product, generate favorable conditions for biological treatment with native bacteria.

In situ biological treatment typically consists of introducing soluble organic carbon to the aquifer (TBEG, 2005). Carbon substrates such as food grade lactate, ethanol, acetic acid (vinegar), molasses, emulsified or vegetable oil can be injected into the groundwater to facilitate microorganism growth and create the reducing conditions needed to chemically reduce soluble COCs such as cadmium and selenium (USEPA, 1999b; Groudev et al., 2001). The carbon substrates are supplied to the subsurface via active or passive injection wells. Mixing in the subsurface can occur via the natural hydraulic gradient or via a recirculation system consisting of injection well/extraction wells. Extracted water is amended with the carbon substrates and injected and drawn through the target treatment zone using extraction wells. The re-circulation system provides for containment and reinjection of any excess electron donor, but uses more energy than the passive flow-injection system.

> Effectiveness: The concept and effectiveness would have to be validated with bench scale and field pilot testing. Effectiveness for the two units is as follows:
>
> Effectiveness in the Alluvial Unit: Moderate to High. In situ biological treatment effectiveness in the alluvial unit for COCs is expected to be high, but could vary due to hydrogeologic conditions.
>
> Effectiveness in the Wells Formation: Low. Effectiveness in the Wells Formation would be limited by the ability to distribute the reagents throughout the COC-affected zone.
>
> Implementability in the Alluvial Unit: High. The equipment and installation techniques are well established and are considered conventional technologies. In the alluvial unit, direct-push technology could be used for application.
>
> Implementability in the Wells Formation: Moderate. Implementation in the Wells Formation would require a smaller number of deep wells and dispersion of the reagents may not be complete.
>
> Cost: Alluvial unit - Moderate capital, low O&M (for a one or two injections) to moderate O&M (if a recirculation system in deployed). Wells Formation - High capital, low O&M.

Site-Specific Considerations: The hydrogeological character of the groundwater systems is critical in determining the effectiveness and implementability of in-situ chemical treatment. The alluvial unit is shallow and unconsolidated and is therefore easy to treat with a large number of borings. The Wells Formation has to be accessed with deep bedrock drill holes, but has higher permeability and injected reagents would have greater dispersion. The chemical composition of the groundwater (e.g., species present and competing ions) and aquifer matrix also will affect the effectiveness of the biological treatment.

Potentially Applicable Areas: All areas of groundwater contamination, but may have limited effectiveness and implementability in the Wells Formation.

Decision Rationale: In-situ biological reduction is likely to be effective for remediating Site COCs in groundwater. Implementation in the alluvial unit is straightforward, whereas, implementation in the Wells Formation is very complex and would be hard to demonstrate effectiveness. However, a biological application in the Wells Formation could be less expensive compared to chemical treatment. Application of in-situ biological treatment may be best applied in the alluvial unit via a PRB as discussed above.

Retained?: Yes - Alluvial unit; No - Wells Formation.

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APPENDIX C

COMMENTS AND COMMENT RESPONSE DOCUMENTS

APPENDIX C-1

A/T Comments on *P4's Ballard Mine Feasibility Study Report, Memorandum 1 – Site Background and Screening of Technologies, Draft Rev 0, March 2015*

Transmitted to P4 on May 15, 2015

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
IDAHO OPERATIONS OFFICE
950 West Bannock, Suite 900
Boise, Idaho 83702

May 15, 2015

Molly R. Prickett
Environmental Engineer
Monsanto Company
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1853 Highway 34
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Re: A/T comments on P4's *Ballard Mine Feasibility Study Report, Memorandum 1 – Site Background and Screening of Technologies, Draft Revision 0, March 2015.*

Dear Ms. Prickett,

The Agencies and Tribes (A/T) have reviewed the above referenced deliverable, submitted pursuant to the Administrative Settlement Agreement and Order on Consent/Consent Order for Performance of Remedial Investigation and Feasibility Study at the Enoch, Henry, and Ballard Mine Sites in Southeastern Idaho (or 2009 AOC). This letter transmits comments on this technical memorandum.

We will be available to discuss and clarify these comments during our next conference call, and could also arrange for a separate call or meeting to discuss comments. Please contact me if you have questions. I can be reached at 208-378-5763 or electronically at tomten.dave@epa.gov.

Sincerely,

//s//

Dave Tomten
Remedial Project Manager

cc:

Mike Rowe, IDEQ - Pocatello
Sandi Fisher, US FWS - Chubbuck
Kelly Wright, Shoshone Bannock Tribes
Susan Hanson (for the tribes)
Mary Kaufman, FS – Pocatello (electronic version only)
Colleen O'Hara-Epperly, BLM (electronic version only)
Vance Drain, MWH (electronic version only)
Cary Faulk, Integrated-Geosolutions (electronic version only)
Talia Martin, Shoshone Bannock Tribes (electronic version only)
Bob Blaesing, BIA (electronic version only)
Dennis Smith, CH2MHill (electronic version only)

Gary Billman, IDL – Pocatello (electronic version only)
Charles Allbritton, EPA Records Center (electronic version only)

Feasibility Study Tech Memo #1 for P4's Ballard Mine

General Comments

GC#1. Please revise terminology and use the term preliminary remediation goal (PRG) in the document rather than proposed cleanup level (PCL). Use of "PRG" mirrors the language in the NCP and is consistent with practice within EPA Region 10. In the Record of Decision phase, the "PRG" nomenclature (and sometimes the value itself) will be changed (and locked in) to the term "Cleanup Level" or "Remediation Goal."

[Body Response]

GC#2. In draft Tech Memo #1, P4 proposed establishing soil PRGs = RBCL+BTV. This approach is a non-starter as it would set soil PRGs above upper threshold levels of the background data set, and because there is no support for this approach in policy or guidance. See also specific comments on this approach below. For soil, the methodology for establishing PRGs is a typically a step-by-step process involving first calculating concentrations of COCs in soil at an acceptable risk level (RBCLs), and then modifying the risk-based levels by considering ARARs, target risk range for various receptors, technical limitations, uncertainty, and other factors including background. There is no rigid formula for this analysis, and the process must consider a variety of factors to achieve risk management goals. In this case, because RBCLs are low relative to background, consideration of background will be a key driver in establishing soil PRGs.

At this point, based on the information provided, the A / T is not prepared to provide specific direction on a methodology for establishing soil PRGs. To advance this issue toward resolution, we believe it would be appropriate to consider some additional information or graphical presentation of existing information.

Specifically, we are requesting:

- RBCLs for all COCs for other human health exposure scenarios (in addition to residential scenario), and for all ecological receptors (in addition to the most sensitive).

- Index plots of key COCs grouped by subpopulations with potential decision statistics displayed.

- Summary table reporting USLs, UPL, and UTLs for various COCs to illustrate differences.

- A description of how soil PRGs would be applied using the amount and type of data available to make cleanup decisions, in terms of decision rules.

This information will provide additional insight that will allow for more informed and balanced risk management decisions. Proposed decision rules regarding application of PRGs will need to consider the potential for uptake by veg over an appropriate soil depth and consider how variability over a source area (including presence of hot spots) would be handled.

GC#3. Revise TM#1 to fully incorporate results from the Tier I Ballard Mine Radiological Risk Calculations, which showed that risks to humans are driven by Radium. In addition, the next version of TM#1 should present RBCLs and proposed PRGs for radiological COCs.

GC#4. There are various statements throughout the document regarding potential bias in the background soil data set. The next version of TM should be revised to include the new provisional background soil data and summary statistics, with a note that the background report is not yet final. Inclusion of this information eliminates the need to speculate regarding bias. Please delete speculative statements regarding potential bias.

GC#5. Considering empirical radiological data were obtained in 2014, the speculative statements about modeling from uranium and background radionuclide levels need to be removed from subsequent drafts of the FS memoranda, and replaced with discussion comparing findings from 2014 characterization work with results from secular equilibrium modeling.

GC#6. Where Vegetation is considered a secondary media, it should be discussed how the remedial technologies will impact COC / COEC levels in vegetation.

GC#7. We note that the Area-Wide study (IDEQ 2001) is only mentioned in historical references, and the RI appropriately relied primarily on site specific information. Please note that Tribes have requested that data from the study not be used.

GC#8. ARARs – In the interest of getting comments out on TM#1, these comments include only limited comments on ARARs. The A / T intend to provide additional comments on potential ARARs in the coming weeks, as potential ARARs are identified and compiled. We anticipate that comments will be provided within the next two weeks.

Specific Comments

TOC. Add list of appendices and an Acronyms and Abbreviations section to the Table of Contents.

1.1. Both the BLM and the US Fish and Wildlife Service are in the Department of Interior. Please correct the paragraph to make this fact more explicit.

1.2. Delete the second "for each."

1.3.1. Suggest moving discussion of risks and future land uses at the Shop Area to 2.3.1. (Starting with "The Ballard Shop was investigated…." through end of section 1.3.1.)

1.3.2. Revise to clarify that Monsanto (not P4) owned and operated the plant and mine during the operational phase of the project.

1.4. Delete "and" to read "(5) geology, (6) hydrogeology."

1.4.6. Insert "and" to read "generally unconfined and may interact."

1.4.6. Change to "Dinwoody Formation."

1.4.7. Please visit the Idaho Fish and Wildlife Office web site to access the most current Endangered Species information (http: / / www.fws.gov / idaho / species / IdahoSpeciesList081414.pdf). Only Canada lynx are Federally listed in Caribou County; the greater sage-grouse are a candidate species.

1.4.8. The land use section provides a general discussion on uses around the area, however more specifics on adjacent ranch properties (where site-related contamination is known to have migrated) should be added. In addition, add language describing the potential for use of Site by Tribes, such as: "the Ballard Mine is located in the vicinity of federal lands where there are tribal cultural activities, specifically hunting and gathering." Also revise to indicate that the scattered ranches and farms in the area use groundwater for domestic use.

2.1. In various places in section 2.1 the narrative refers to "screening levels" for various media. To assist reader, please define at first usage to avoid potential confusion.

2.1. Reword as the sentence reads awkwardly especially "…leading from the Site as shallow groundwater plumes leading from the source area."

2.1.1. First sentence – "Concentrations of most constituents in the upland soil samples collected across waste rock dumps, mine pit backfill, and the haul road are elevated above screening and background levels, for several metals / metalloids.": State what the screening level is and its basis and the range that the COCs are above the screening and background levels. This comment also pertains to other media that describe sample results above screening / background levels.

2.1. Note presence of radiogenic elements in the waste materials, and associated nature and extent of daughters including radon gas and gamma.

2.1. The "key findings" of the nature and extent of contamination needs to also describe whether contamination has migrated off the mined areas and off the P4 property.

2.1.2. The vegetation discussion should describe the presence and abundance of selenium accumulator and hyperaccumulator species.

2.1.4. Delete "the" to read "and other constituents."

2.1.5. Change to ". (i.e., exceed levels in a single event at a single location, exceed in a very few locations [e.g., dump seeps], or exceed in total but not dissolved fractions)."

2.2. This paragraph describes two scenarios within the conceptual site models of where waste rock is placed but does not state the impact of these two waste placement locations and how this influences the fate and transport of CoCs for each scenario. Please add this discussion.

2.3.1. First sentence states that "conservative" assumptions were made with respect to the HHRA. Either describe how the assumptions were conservative, or refer to subsequent discussions where the conservativeness is discussed, or delete if the conservativeness of assumptions cannot be described and documented.

2.3.1. Considering ranching is a current use on areas where contamination is known to be present, it is unclear why this exposure scenario is considered only as a future use. The current and future land use descriptions in this section are not consistent with the descriptions in the RI and are not consistent with the scenarios considered in the risk assessment (RA). All scenarios evaluated in the RA were considered to be both current and future use with the exception of the hypothetical future residential scenario. The FS memo needs to be revised to accurately reflect the current uses and those evaluated in the RA.

2.3.1. Human health risks are presented by medium only, which does not accurately reflect the total exposure to potential receptors. Cumulative risks from exposure to all media were provided in the RA and need to be summarized in the FS.

2.3.1. Replace "likely to be overestimated" with "may be." Also delete (2) as background concentrations will not change site risks.

2.3.1. Here and elsewhere, define, and use care in, use of the terms Site and Mine Area. Note that the Site includes mine features such as pits and dumps, and the Site would include all areas where contaminants have come to be located. Thus the Site would include land near the mine features that are impacted by surface water runoff, or include plumes of contaminated groundwater. Consistent with this direction, delete language on page 2-7 indicating that future subsistence, ranching and residential uses are unlikely to occur in the future. Seasonal ranching is a known current use, and subsistence and residential (farm or ranch on the Site) are reasonably foreseeable at least for some portions of the Site. In addition, delete or revise final sentence of 2.3.1 as it may be necessary to control future uses of some areas downgradient of the mine dumps for some period of time (e.g., east side of Ballard) due to risks associated with releases of contaminants to GW and SW.

2.3.1. The FS memo states that, "The Native American, hypothetical future resident, and seasonal rancher were evaluated to determine if land use controls and / or remediation are required to protect future subsistence, residential or seasonal ranching land uses…" Some of these are current use scenarios (e.g., on-site grazing of cattle) and there is offsite contamination on private lands currently used for ranching. The FS memo needs to be revised to accurately describe the current uses within the extent of contamination and the risks to these users.

2.3.2. First usage of "HQ" – spell out

2.3.2. The FS memo indicates that "based on the changes to the revised background data set, it may be necessary to recalculated ecological HQ estimates." Site risks will not be impacted by the new background data. Instead, recalculation of the background risk may be useful to help risk managers understand the risk attributable to background.

Include paragraph noting that eco risks were estimated using the data collected, which did not include collection of plants known to hyper-accumulate selenium. Add language explicitly acknowledging that plants that hyper-accumulate Se are known to be present in some nearby mining disturbed areas, and these facts contribute uncertainty to risk estimates. Because such plants are known to be present in mining disturbed areas, there may be additional risks associated with acute exposure scenarios for hot spots. These risks are not reflected in risk estimates. Ditto for section 2.3.3 for livestock.

2.3.3. Note that horses may have been known to graze at some Sites in the mining district. Revise to clarify that while grazing is not currently allowed on lands controlled by P4, there are portions of the Site below the dumps where seasonal grazing is a known current land use.

2.3.4. The statement for excluding thallium as a COC seems unsubstantiated. Please state basis of exclusion —- (i.e., only detected once in X samples, or similar).

2.4.1. Add "manganese" to this list based on the first sentence in the next paragraph.

Table 2-1. Include summary information on radiological risk, or add new table.

Table 2-1. Total cumulative risk for each receptor (exposure scenario) should be provided.

Table 2-1. The incremental HI for culturally significant plants in upland soils appears to be incorrectly calculated. A revise to the HI is necessary.

Table 2-1. The use of footnote d is confusing and appears to be in error. Footnote d apparently indicates dissolved contaminant levels were used, however this footnote is used for sediment which is nonsensical. This footnote is also used for cattle-surface water. Unlike protection of fish, which often uses dissolved levels for comparisons with water quality criteria, cattle would be exposed to total metals concentrations. Revisions to the table are necessary.

Table 2-4. Revise table or include additional table to reflect radiological COCs.

Drawing 2-2. Does this drawing also include co-located sediment sample locations? Revise accordingly.

3.0. Beginning with the title of Section 3.0 and throughout the rest of the document: Please revise terminology and use the term preliminary remediation goal (PRG) at this stage of the process, rather than "proposed cleanup level". Use of "PRG" mirrors the language in the NCP and is consistent with practice within EPA Region 10. In the Record of Decision phase, the "PRG" nomenclature (and sometimes the value itself) will be changed (and locked in) to the term "Cleanup Level". Use of the term RBCL is useful and helps to clarify stepwise process for developing candidate PRGs.

3.1. Clarify that the list of potential ARARs provided is preliminary. ARARs are selected and finalized in the ROD. This process will also allow for further discussion and evaluation of the relevancy and appropriateness of some potential ARARs using the factors in 40 CFR 300.400(g)(2).

3.2.1. Please provide citation to support final sentence of this section. Note that language regarding consistency of application applies to state ARARs.

3.4. Section 2.2 identified the contaminant pathway between surface water and groundwater. Considering this contaminant transport mechanism occurring at the site, it seems appropriate to include "Hydraulic Isolation" as a General Response Action (i.e., remedial measures to minimize the transport of contaminants from surface water to groundwater and vis versa.). Although it appears this concept may be partially captured under Containment (Sediment Control Basins) in Surface Water Table 4-4 and under Containment (Vertical Barriers) in Groundwater Table 4-6.

Table 3-3. Federal Location-Specific ARARs: The Bevill-exemption of mining wastes should be specifically identified and summarized in the ARARs tables. The Bevill exemption to RCRA provides an exemption of mining wastes as hazardous wastes (Subtitle C), but the mining wastes are still classified as RCRA solid wastes (Subtitle D). This is an important determination when addressing mine waste piles or treatment stream wastes.

Table 3-3. Please add the Federal Migratory Bird Treaty Act to this table, as it is an ARAR at the Site.

3.5. Last two sentences stating process of modifying Preliminary Cleanup Levels (aka PRGs): In this discussion it should be explained that it is at the ROD phase when the PCLs become set (legally binding) as cleanup levels.

3.5. The sentence states that "Vegetation is a secondary medium and adverse effects to this medium will be addressed through cleanup of primary medium (soils and sediment)…" To prove that the primary medium is effective at isolating COECs from receptors and meeting RAOs, it is recommended that corresponding concentrations of Se and other COECs in vegetation be calculated and utilized as performance targets. This information may aid in evaluating the effectiveness of remedial actions taken. In addition, the ability of a remedy to meet soil RAOs will depend on the selected PCLs (PRG) for soil, as well as design considerations that account for rooting depth of reclamation vegetation and perhaps other factors. The alternatives developed in TM#2 will need adequate detail and definition regarding soil remedies (thickness of cover profile for example) to evaluate effectiveness, costs and other criteria.

3.5. RBCLs (for arsenic) were calculated and reported at a target cancer risk of 10^{-4}, which exceeds Idaho DEQ's target risk of 10^{-5} and the EPA 10^{-6} "point of departure" in the stepwise process for establishing PRGs. For carcinogens, RBCLs should be presented for a range of risk levels within the DEQ and EPA target risk range, including 10^{-4} 10^{-5} and 10^{-6} to provide clarity and transparency to the process of establishing PRGs. The RBCLs may be revised from the point of departure by considering ARARs, uncertainty, background and other factors during subsequent steps in the development of PRGs.

3.5. Calculating preliminary cleanup levels for soil or sediment for a given COC / COEC by adding background concentrations (upper threshold values) and the lowest risk based screening level together would not appear to protect resident receptors from toxicological effects. This observation is based on the fact that if chemical concentrations in soil and sediment exceed a RBCL because background is added to the RBCL, the receptor for which the PCL was derived would potentially be exposed to a COC / COEC above a given toxicity value. Thus, by nature, the proposed PCLs are not conservative in that they would appear to be permitting some level of risk to sensitive receptors exposed to Site media. Despite the cited cases (in the document) in which this methodology (PCL=background + RBCL) was used, it does not appear to be adequately protective of receptors in cases where both background and RBCLs are exceeded. Also note that in the FMC example cited, that an estimate of central tendency was used as a starting point. Thus the proposed additive approach using a USL as a starting point is unacceptable. See also general comments on use of background in establishing PRGs.

3.5. Section 3.5 describes the PRGs / PCLs as levels that are based on site-specific risk based cleanup levels protective of human and ecological receptors. Then, PCLs are described as a summation of the risk based cleanup level and background. Therefore, the PCLs are above levels that are protective of humans and ecological populations. The summation of the estimated upper range of background with risk based levels is not appropriate. For example, the proposed PCL for upland soil is equivalent to a LOAEL-based hazard quotient of 4.

Table 3-5. The RAOs must be revised to reflect program management expectations articulated in the NCP (40 CFR §430(a)(1)(iii)) and to be protective and definitive for all relevant exposure pathways. The FMC Plant OU ROD provides a good example of acceptable detail for description for some RAOs:

1. Prevent human exposure via all potential exposure pathways (external gamma radiation exposure, inhalation of radon in potential future buildings, incidental soil ingestion, dermal absorption, and fugitive dust inhalation, ingestion of fruit and vegetables) associated with soils and solids contaminated with COCs thereby resulting in an unacceptable risk to human health assuming current or reasonably anticipated future land use

2. Prevent potential ingestion of groundwater containing COCs in concentrations exceeding risk-based concentrations (RBC) or ARARs, or site-specific background concentrations if RBCs or ARARs are more stringent than background

3. Reduce the release and migration of COCs to the groundwater from BALLARD MINE sources resulting in concentrations in groundwater exceeding RBCs or ARARs, or site-specific background if RBCs or ARARs are more stringent than background

4. Restore groundwater that has been impacted by the Facility to meet RBCs or ARARs for COCs, or site-specific background levels if RBCs or ARARs are more stringent than background

5. Reduce the release and migration of COCs to surface water from BALLARD MINE sources at concentrations exceeding RBCs or ARARs, including water quality criteria pursuant to Sections 303 and 304 of the Clean Water Act.

6. Thus, please review the RAOs in Table 3-5 and revise as needed to reflect a similar level of detail. In particular, RAOs groundwater and surface water focus on preventing or reducing exposure. These should be revised to include explicit statements that groundwater and surface waters shall meet ARARs to the extent practicable. In addition, RAO for mine waste rock / soil for protection of eco receptors should reference uptake by vegetation and consumption by eco receptors.

Table 3-5. Delete reference to livestock health from the RAOs due to unresolved policy questions regarding whether it is appropriate to trigger action or base remedy selection decisions on protection of livestock. Because protection of livestock is an important concern of stakeholders, it would be appropriate to evaluate and disclose information on whether the alternatives are protective of livestock.

Table 3-5. What are "acceptable risk levels" in vegetation and what standards for human health and environment determine it's acceptable?

3.5. The PRG / PCL discussion incorrectly cites the FMC Plant OU to support a Risk + Background level approach. FMC utilized a Risk + Background approach, but only for radium; not for metals or other constituents. FMC also used a central tendency estimate of background, which is not comparable the proposed 95% USL (upper simultaneous limit). Because background was estimated as a central tendency, it was necessary to add a risk increment to delineate background in the field. The sum of the central tendency background estimate and a 10^{-4} cancer risk based level is significantly less than the sum of the 95% USL and 10^{-4} cancer risk based level and is likely less than the 95% USL (without the additional risk increment).

Table 3-7. Assuming the radiological data collected in 2014 also show unacceptable risk from radium, PRGs / PCLs for radiological elements will need to be added to subsequent drafts of the FS documents.

Table 3-7. Suggest replacing the ND for molybdenum in sediment with a < (detection limit); this may provide the risk manager with some indication of the potential contribution of background.

Table 3-7. Suggest Changing "Media" in first column to "Primary Media" because vegetation is not put on these tables since it is considered secondary.

Table 3-7. RBCLs for Uranium should be recalculated using a revised RfD, due to severe problems with the IRIS profile (it used a 1949 study that would no longer be considered adequate). I'm now recommending the 2013 ATSDR, subchronic, oral MRL (http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=440&tid=77). It's better supported than the MCL-

RfD or the IRIS value, despite being subchronic. If necessary, we could convene a meeting of a subgroup of subject experts to further discuss this matter.

4.1.1 and 4.2.1. Include paragraph noting that eco risks were estimated using the data collected, which did not include collection of plants known to hyper-accumulate selenium and that this is a source of uncertainty. Because such plants are known to be present in mining disturbed areas, there may be additional risks associated with acute exposure scenarios where receptors may ingest selenium hyper-accumulators. These risks are not reflected in risk estimates.

4.1.1. Delete reference to risk to livestock. See previous Table 3-5 comment.

4.1.2. Tribes have an updated list of culturally significant plants for the Shoshone and Bannocks. The CS plants discussed in the FS are based on previous information, not the updated version of the CS plants. It should be noted in footnotes, that this section does not reference the most recent version of CS plants. The CS plant list was revised after the referenced sampling.

4.1.3. See comment above on need to add language recognizing that achieving RAOs must consider cover profile in addition to PRGs / PCLs for soil. Develop a performance target for vegetation uptake of metals, particularly selenium. General specifications for a cover / cap will need to be developed in TM#2 in order to evaluate effectiveness and cost.

4.1.3. Selected remedial alternatives for primary media address unacceptable risk posed by vegetation only if any seed mix or replanting does not include selenium-accumulating plants as mentioned in Appendix B. Include language here.

4.1. The proposed approach to <u>not</u> monitor vegetation for COC / COEC levels and subsequently use such information for remediation evaluations does not appear to be justifiable nor protective of receptors. Although vegetation is a secondary media, it is the conduit of COC exposure for many receptors and thus should be monitored in order to assess the efficacy of primary media remediation. If COCs in vegetation fall above a given level of concern (e.g., a screening value or performance target), the efficacy of remediation of soil or sediment would come into question. Thus, please provide decision criteria for the evaluation of remediation efficacy that would include vegetation monitoring and additional assessments of remediation efficacy. If vegetation with elevated COCs is growing in primary media that are below cleanup values, risk may still exist for ecological / human receptors. Such a condition may occur if cleanup values for primary media are above both RBCLs and background levels as currently proposed.

4.2.1. Vegetation with COCs above levels of concern that is growing in primary media that has COCs below PCLs may continue to present a risk to receptors. Thus, as stated in the previous comment, please provide decision criteria and/or performance targets that could be used to trigger further assessment of the efficacy of remediation of primary media.

4.2. This paragraph is somewhat confusing. It states that establishing actions for contaminated surficial materials that are associated with the waste rock is being deferred until the Remedial Design and / or RA Work Plan phase with the assertion that addressing waste rock and uplands soil will also address these media? Please clarify by further describing or referencing information on the nature and extent and volumes of these associated surficial materials.

4.2. Seasonal Ponds: Last sentence reads: "This section then deals specifically with only upland soils and waste rock found in mine dumps throughout the Site." This last sentence attempts to clarify the limitations of the upland soils and waste rock category, however, the opening paragraph of Section 4.3 then states that "seasonal ponds" are excluded from Site Surface Water and are part of the upland soils and waste rock category (Section 4.2). Clarify in Section 4.2 that the seasonal ponds within the upland soils and waste rock area are considered part of this area and the process options / technologies considered therein.

4.2. Change to "The waste rock is."

4.2. Consistent with general comment above, add language in this section to address radiological contaminants.

4.2.1. This is true for vegetation only if no selenium-accumulating plants are part of any reclamation efforts. Revise as needed.

4.2.2. The paragraph makes the following statement: "For example, the data suggest that regrading and some type of cover system for the waste rock would be the primary technologies and process options for the Site. Some technologies and process options might be applicable at sites with less volume and aerial distribution, but for large volume mine sites, such as the Ballard Site, the list of technologies that are practical is limited." It is unclear what "data" is being referred to, but if it is volume alone, then that is not a basis to eliminate technology options *at this stage* of the FS evaluation. If a technology or process option has the capability of addressing the risk and is implementable, then that process option is generally not eliminated at this phase. It would, however, be appropriate to eliminate some alternatives for large volume wastes during *later phases* of the FS evaluation. Please provide more substantiated discussion and the specific data being considered in order to determine whether to eliminate a process option at this phase.

4.2.4.1. "Site surface water" should be changed to "upland soil / waste rock"

4.2.4.4. Delete "thermal" as according to Table 4-2 all ex-situ treatments are eliminated.

4.2.4.5. Insert "to" to read "and aeration to reduce."

4.3.1. First sentence, reference to cleanup levels of Table 3-6: at this FS stage of the CERCLA process, these values are considered Preliminary Remediation Goals (PRGs) (see comment above on Section 3.0). Also, other locations in this paragraph and document refer to "cleanup levels" when it should be PRGs

4.3.1. Suggest changing "poor aquatic quality" to something like "poor quality aquatic habitat incapable of supporting fish populations."

4.3.2. Reference to Table 4-3 and runoff discharge – are these measurements considered the "peak" runoff discharges? Please clarify.

4.3.2. Seasonal Ponds: this paragraph describes the seasonal ponds and then refers the reader back to Section 4.2 where seasonal ponds are supposedly included and addressed as part of Section 4.2 —- however, Section 4.2 and Table 4-2 make no mention of "seasonal ponds" and how they will be addressed as part of the Upland soils and Waste Rock category. If seasonal ponds are going to be included in Section 4.2, please add appropriate discussion.

4.3.4.2. Change to "Site, or infiltrates and discharges."

4.3.4.4. Define "POTW."

4.4.1. Delete the space to read "vanadium."

4.4.1. Eliminate the underline to read "fall within."

4.4.1. Insert "the" to read "near the Site."

4.4.1. Change "come" to "comes" for subject-verb agreement.

4.4.2. Last sentence states: "The area and volume assumptions listed above will be refined in subsequent iterations of this FS when the Site specific clean-up levels are approved." Note that site-specific cleanup levels are approved or finalized in the ROD. Initial indications of concurrence may be provided by the A / T during the FS phase, but typically cleanup levels are not set until the ROD.

4.4.2. The 30-foot average is representative not conservative as the Respondents have stated. Please change "conservative" to "representative".

4.4.2. Delete the period after document to read "document (see Section 2.3)."

4.4.4.4. Change "plant" to "plants."

4.5.4.5. Delete last sentence as this pertains to in-situ and this section deals with ex-situ treatments.

Table 4-2. Vertical Barrier: Sheet Pile or Grout Wall: I agree that it makes sense to eliminate this process option for upland waste rock piles, but it seems like its elimination should be based on the fact that the waste rock piles are unsaturated, and as such, how would COC / COECs be expected to migrate from the soil that is also unsaturated? Restate the logic for elimination of this process option based on the lack of pathway for migration.

Table 4-2. In line 2, change to "will result in the net reduction."

Table 4-2. In line 3, change to "direct exposure to COCs / COECs."

Table 4-2. Looks like this row should be under Ex-Situ Treatment. Revise accordingly.

Table 4-2, In line 3, is "fixation" the same as "solidification?" If so, then the language is fine as written. If not, change to "solidification."

Table 4-2, Removal and Disposal, Physical, Separation: For completeness, the site specific considerations describe a slurried soil separation process only, when physical waste rock separation using screens and grizzlies is more commonly used. However, based on the waste rock characteristics, it is agreed that separation will likely not be effective at this site and should be eliminated.

Table 4-3. "Annual" Runoff Discharge category: the notes on this table indicate that these measurements are typically made in May. This appears to be a yearly "peak" discharge measurement rather than an annual discharge (e.g., total for the year)? Please clarify.

Table 4-4. Retention Basins / Serpentine Channels: Both of these process options for the Containment GRA claim a benefit of trapping sediment. However, how will high flow events that are likely to remobilize the trapped sediment be addressed? Through routine O&M and sediment removal?

Table 4-4. Include the footnote for the "(1)" superscript.

Table 4-4. Delete "Ex-Situ Treatment (continued)" or move to next page and add to all other tables accordingly.

Table 4-5. Monitored Natural Recovery: It is not clear from the table's description of how the "natural recovery" process is to occur. Is it assumed that once the upstream sources of contaminated sediment / runoff are remediated that "clean" sediment will be distributed on top of the current contaminated sediment and then somehow plants will grow up through this newer clean sediment and that their rooting systems will no longer be exposed to the underlying contaminated sediment. Please provide a clear description of how the natural recovery mechanism is envisioned to work, in both text and table.

Table 4-5. Sediment / Riparian Soils: if the risk concern is for current / future Native Americans eating aquatic plants that are growing in contaminated sediment, it seems appropriate that the "Removal" process option also include a replacement with clean sediment and replanting of the aquatic vegetation species. Was this not considered?

Table 4-6. The regarding / capping source control approach for contaminated groundwater plumes: This approach may reduce future contaminants from entering the groundwater, but does nothing for the current plume of contaminated water. Perhaps regrading / capping can be a component for groundwater remediation when paired with another process option. Please describe how regrading / capping addresses the current groundwater plumes.

Table 4-6. Change "Surface Water use" to "groundwater use."

Table 4-6. In line 2, define "UIC."

Table 4-6. Delete "Chemical Treatment."

Table 4-6. Add a cell with "Thermal" in the same row as "Thermal Desorption."

Tables 5-1 & 5-2. Include a footnote similar to the footnote in Table 5-3.

Table 5-1. In line 3, insert "be" to read "may not be appropriate."

Table 5-2. Change page number to 1 of 1.

Table 5-2. In line 1, change "like" to "likely."

Table 5-3. Increase the cell size or revise the paragraph spacing to include all the language.

Table 5-4. Delete decision rationale related to administrative challenges for discharge to surface water, reference that limits would be "overly stringent," or characterization that access across private lands is a technical issue. Permits would not be needed for discharge of effluent, although equivalent restrictions (similar to effluent limitations) would still need to be developed. Also, this would not preclude discharge to tributary streams, such as has been implemented during the treatability study.

Appendix A. It is difficult to replicate the RBCLs, so as during the review of the BRA, it would be useful to for P4 to provide the actual calculation tables to review the inputs and equations. Please provide all or at least some example tables for review.

A2.2. According to this section, PCLs were not calculated for seasonal ranchers because it was determined to not be a high risk receptor. However, Table 2-2 of the main text indicates that risk to seasonal ranchers is high (HI>40) through the consumption of cattle. How will this be addressed in the FS?

A2.1.2. RBCLs are called out as risk based screening levels, which should be revised to be risk based cleanup levels. Also, see comments above regarding terminology and use of PRG rather than PCL at this stage of the process.

A2.2. There are several mentions of using the linear relationship between measured soil and plant tissue concentrations for the calculation of RBCLs, however it remains unclear how these were developed. Is it based on site-wide means, site-wide 95% UCLs, etc.? Clarification is necessary to complete the review of the RBCLs. This also occurs for other relationships (e.g., soil to invertebrates and vertebrates) with some describing using the Microsoft Excel Solver tool. Essentially, insufficient information has been provided in Appendix A to understand the inputs and methods used for calculating the RBCLs.

A3.4. The last sentence does not make sense and probably should be changed from "for riparian sediment, only" to "for riparian soil, only."

Table A-1. The uranium RBCL for elk consumption by Native Americans is nonsensical as there cannot be more than 1 million mg in a kg. Revision is necessary.

Appendix B

B.2.3.1. Explain why if soil caps have limited effectiveness would you expect soil caps to "may reduce if not eliminate leaching?"

B.3.6.1. Change to "Solid / water separation is not retained as standalone …"

B.3.7.1. Reword the sentence beginning with "The biological processes …" as it reads awkwardly.

B.4.4. Change to "which would require additional."

B.5.2.1. Change to "applicable to all the areas."

B.5.5.1. Change to "For the alluvial system, the technology would likely have …"

B.5.5.2. Change to "May be a viable technology …"

B.5.6.1. Delete "and" to read "COCs including sulfate and TDS."

Editing Comments

General Editing Comments
For consistency ensure there is a following comma to read "e.g.," and "i.e.," throughout the document.
Be consistent as to whether it is "snow melt" or "snowmelt."
Be consistent on use of a hyphen for "in-situ," and "ex-situ."
Be consistent on use of a hyphen and capitalization for "Site-specific."
Check all instances to see if "off-Site" or "off Site" is correct.
Generally "whereas," like "however," is preceded by a semi-colon when separating clauses. Revise accordingly.

Section	Page	Paragraph	Specific Editing Comments
1.1	1-1	1	Change to "Shoshone-Bannock Tribes (Tribes)."
2.0	2-1	1	Change to "COCs / COECs."
2.3.3	2-8	5 (last)	Change "shown and" to "shown in."
2.4	2-9	Bullet 1	Change "Drink" to "Drinking."
3.2.1	3-1	Quoted language	Unless it is how it appears in the quote, change "……" and "..." to ellipses.
Table 4-6	1 of 4	Row Containment / Vertical Barriers / Extraction Trenches	In line 3, delete the second "in the."
Table 4-6	2 of 4	Row Removal and Disposal / Disposal / Recycle / Reuse	In line 3, delete the second period.

Section	Page	Paragraph	Specific Editing Comments
Table 4-6	3 of 4	Row 1 (non-header rows)	Delete the line between Physical and Chemical Treatment Technologies as they are all Ex-Situ Treatments.
Table 4-6	3 of 4	Row Ex-Situ Treatment / Physical / Membrane Technologies (RO / ED / NF)	In line 3, insert a period between "effluent" and "Membrane."
Table 4-6	3 of 4	Row In-Situ Treatment / Chemical / Chemical Injection (Oxidation / Hydrolysis)	In line 5, insert "in" to read "resulting in long-term."
5.0	5-1	Bullet 2 (Implementability Evaluation	Italicize 'RI / FS Guidance" for consistency.
A2.2.2	A2-3		Change "Native America" to "Native American"
B.2.3.1	B-5	Implementability	Change to "COCs / COECs."
B.3.4.1	B-15	2 (last)	Change "pond" to "ponds."
B.3.4.1	B-16	Decision Rationale	Change "like" to "likely."
B.3.6.1	B-23	Site-Specific Considerations	Change "efficiently" to "efficiency."
B.3.6.3	B-27	Site-Specific Considerations	Change "basins" to "basin."
B.4.2.1	B-32	Bullet 2 Fencing	Change to "COCs / COECs."
B.4.2.2	B-35	1 (partial)	Insert a hyphen to read "(pre-remedial action)."
B.4.4	B-42	Bullet 2	Change "soil" to "soils."

Section	Page	Paragraph	Specific Editing Comments
B.5.1	B-42	Cost	Underline "Cost:" for consistency.
B.5.2.2	B-44	1	Change "need" to "needs" for subject-verb agreement.
B.5.2.2	B-45	2	Change "appropriate candidates" to "appropriate candidate."
B.5.4.1	B-48	Implementability in the Wells Formation	Change "formation" to "Formation."
B.5.6.1	B-59	Site-Specific Considerations	Change "efficiently" to "efficiency."
B.5.6.1	B-60	Site-Specific Considerations	Change "efficiently" to "efficiency."
B.5.6.1	B-61	Partial bullet	Change "each technology in this group have unique" to "each technology in this group has unique" for subject-verb agreement.
B.5.6.1	B-61	Decision Rationale	Change "blended" to "blending."
B.5.6.4	B-65	Cost	Insert a comma to read "(alluvial and / or Wells Formation)," for consistency.
B.5.7.1	B-70	Decision Rationale	Delete "via."
B.5.7.2	B-70	1	Change "principals" to "principles."
B.5.7.2	B-70	1	Insert "for" to read "favorable conditions for biological treatment with native bacteria."
B.5.7.2	B-70	2	Delete the comma to read "cadmium and selenium …"
B.5.7.2	B-71	Site Specific Considerations	Change "character of the groundwater systems are" to "character of the groundwater systems is" for subject-verb agreement.

Section	Page	Paragraph	Specific Editing Comments
References	B-72	Smolen citation	Change period to comma to read "A.L. Lanier, 1988." for consistency.
References	B-73	USEPA.2003 citation	Change period to comma to read "USEPA, 2003." for consistency.

APPENDIX C-2

A/T Supplemental Comments on Potential ARARs identified in *P4's Ballard Mine Feasibility Study Technical Memorandum 1, Draft Rev 0, March 2015*

Transmitted to P4 on May 28, 2015

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
IDAHO OPERATIONS OFFICE
950 West Bannock, Suite 900
Boise, Idaho 83702

May 28, 2015

Molly R. Prickett
Environmental Engineer
Monsanto Company
Soda Springs Operations
1853 Highway 34
Soda Springs, Idaho 83276

Re: A/T supplemental comments on potential ARARs identified in P4's *Ballard Feasibility Study Technical Memorandum 1 (March 2015)*

Dear Ms. Prickett,

The Agencies and Tribes (A/T) have reviewed the above referenced deliverable, submitted pursuant to the Administrative Settlement Agreement and Order on Consent/Consent Order for Performance of Remedial Investigation and Feasibility Study at the Enoch, Henry, and Ballard Mine Sites in Southeastern Idaho (or 2009 AOC). Previously, comments were submitted on the entire technical memorandum 1 (TM1), with the exception of the section on ARARs. This letter transmits supplemental comments on potential ARARs that were identified in TM1.

Comments

In TM1, information on ARARs was summarized in a table with limited introductory text. Please include additional introductory text providing some additional context, along the following lines: 1) that the table presents requirements that are tentatively identified as ARARs for the site; 2) potential ARARs will be used in the FS for a couple of uses, including developing PRGs and for use as threshold criteria against which remedial alternatives will be evaluated; 3) potential ARARs in this FS are not binding; 4) final ARARs (as well as final RAOs and cleanup levels/remedial goals) will be developed from the evaluations presented within the FS and set forth in the ROD, and used as performance standards for remedial design and subsequent remedial actions.

In the attachment to this letter we are providing additional comments on specific ARARs, including additional level of detail on the description of previously identified ARARs that would be appropriate and useful to include, as well as a few additional potential ARARs that were not included in TM1 (including ARARs/TBCs pertaining to radiological contaminants, and the Shoshone-Bannock Tribes Soil Cleanup Standards). The information included in the table is intended to supplement the table in TM1 (rather than replace it).

In addition, the ARAR description column should include enough information that readers will quickly understand how it would pertain to actions or alternatives that are contemplated. For ARARs that may drive development of alternatives or elements to be included in alternatives, additional detail may be appropriate. Suggested language for several potential ARARs is included.

As you review the table, you will note that we have added a column for project-specific information. This column may include information on whether or how an ARAR might apply under the circumstances presented at Ballard. Some of the information presented in the existing ARAR description column should be moved to this new column.

We will be available to discuss and clarify these comments during our next conference call, and could also arrange for a separate call or meeting to discuss comments. Please contact me if you have questions. I can be reached at 208-378-5763 or electronically at tomten.dave@epa.gov.

Sincerely,

//s//

Dave Tomten
Remedial Project Manager

Attachment

cc: Mike Rowe, IDEQ - Pocatello
Sandi Fisher, US FWS - Chubbuck
Kelly Wright, Shoshone Bannock Tribes
Susan Hanson (for the tribes)
Mary Kaufman, FS – Pocatello (electronic version only)
Colleen O'Hara-Epperly, BLM (electronic version only)
Vance Drain, MWH (electronic version only)
Cary Faulk, Integrated-Geosolutions (electronic version only)
Talia Martin, Shoshone Bannock Tribes (electronic version only)
Bob Blaesing, BIA (electronic version only)
Dennis Smith, CH2MHill (electronic version only)
Gary Billman, IDL – Pocatello (electronic version only)
Jeremy Moore, US FWS – Chubbuck (electronic version only)
Charles Allbritton, EPA Records Center (electronic version only)

Comments on the level of detail for ARARs and new potential ARARSs and TBCs
Ballard Mine Site

Statutes, Regulations, Standards, or Requirements [a]	Citations or References [b]	General Description	Site-Specific Comments	Potentially Applicable or Relevant and Appropriate or TBC	Chemical Location or Action-Specific
National Historic Preservation Act (NHPA)	16 USC §470f 36 CFR Parts 60, 63, and 800 40 CFR § 6.301	A requirement for a property included in or eligible for the National Register of Historic Places. The NHPA requires federally funded projects to identify and mitigate impacts of project activities on properties included in or eligible for the National Register. This statute and implementing regulations require federal agencies to take into account the effect of this response action upon any district, site, building, structure, or object that is included in or eligible for the National Register of Historic Places (generally, 50 years old or older). If cultural resources on or eligible for the national register are present, it will be necessary to determine if there will be an adverse effect and, if so, how the effect may be minimized or mitigated, in consultation with the appropriate State Historic Preservation Office.	NHPA may be a potential ARAR within site boundaries if historic or archeological sites are found to be present. In addition, may be an ARAR in the case where land is disturbed outside of current site boundaries (e.g., borrow areas).	Potentially Applicable	Action and location-specific

Statutes, Regulations, Standards, or Requirements [a]	Citations or References [b]	General Description	Site-Specific Comments	Potentially Applicable or Relevant and Appropriate or TBC	Chemical Location or Action-Specific
Archaeological and Historic Preservation Act	16 U.S.C. 469 40 CFR 6.301(c)	The Archaeological and Historic Preservation Act requires that for federally approved projects that may cause irreparable loss to significant scientific, prehistoric, historic, or archaeological data, the data must be preserved by the agency undertaking the project or the agency undertaking the project may request DOI to do so. This statute and implementing regulations establish requirements for the evaluation and preservation of historical and archaeological data, which may be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity or program.	If archaeological resources are identified, this act may be a potentially relevant and appropriate ARAR.	Applicable	Location and action-specific
RCRA: Subtitle C—Exemption for Extraction, Beneficiation and Processing Mining Waste	40 CFR 261.4(b)(7)	EPA exempts mining wastes from the extraction, beneficiation, and some processing of ores and minerals, in accordance with the Bevill amendment to RCRA.	Waste rock at the mine sites may meet this exemption.	Applicable	
RCRA: Subtitle C— Hazardous Waste Characteristics	40 CFR 261.20	Generators of solid waste must determine whether the waste is hazardous. A solid waste is hazardous if it exhibits the toxicity characteristic (based on extraction procedure Method 1311).	Applicable to solid waste generated during remediation.	Applicable	
Water Quality Standards	CWA Section 304(a) 40 CFR Part 131	Section 304 of the federal Clean Water Act (33 U.S.C. § 1251) requires that individual states establish water quality standards for surface waters. The implementing regulation establishes the Ambient Water Quality Criteria, which are the minimum requirements for state water quality standards that are protective of aquatic life. Under CERCLA, water quality criteria for the protection of aquatic life are considered relevant		Relevant and Appropriate	Chemical-specific

Statutes, Regulations, Standards, or Requirements [a]	Citations or References [b]	General Description	Site-Specific Comments	Potentially Applicable or Relevant and Appropriate or TBC	Chemical Location or Action-Specific
		and appropriate for actions that involve surface waters or groundwater discharges to surface waters. The federal water quality standards are developed for states to use in development of water quality criteria that incorporate designated uses for specific surface water bodies. The State of Idaho has adopted the federal water quality criteria. Where numeric state water quality standards have not been promulgated, federal numeric water quality standards are considered relevant and appropriate standards. Federal Ambient Water Quality Criteria have been established for short-term exposures (acute criteria) and for long-term exposures (chronic criteria) for protection of aquatic biota.			
Clean Water Act/Water Pollution Control Act	33 U.S.C. 1251	These regulations govern water quality, including water discharged as part of a remedial process. Section 307—Pretreatment regulations under 40 CFR Part 403 provide for limits on discharge to a sanitary sewer system, protecting the municipal system from accepting wastewater that would cause it to exceed its NPDES permit discharge limits. Section 401—Water Quality Certification requires that EPA receive a water quality certification from a state that a given project requiring a federal permit that may result in a discharge to navigable water will comply with the state's water quality standards. Section 402—The NPDES program establishes a comprehensive framework for addressing waste water and stormwater discharges under the program. Requires that point-source discharges		Relevant and Appropriate	Action-specific

Statutes, Regulations, Standards, or Requirements [a]	Citations or References [b]	General Description	Site-Specific Comments	Potentially Applicable or Relevant and Appropriate or TBC	Chemical Location or Action-Specific
		not cause the exceedance of surface water quality standards outside the mixing zone. Specifies requirements under 40 CFR 122.26 for point-source discharge of stormwater from construction sites to surface water and provides for Best Management Practices such as erosion control for removal and management of sediment to prevent run-on and runoff.			
Bald and Golden Eagle Protection Act	16 USC 668 et seq. 50 CFR 22	Prohibits any person from knowingly possessing or harming a bald or golden eagle, part of or complete nest, egg or part of without being permitted to do so.		Applicable	Location
Fish and Wildlife Coordination Act	16 USC 661 et seq., 16 USC 1531 - 1566 40 CFR 6.302(g)	Requires Federal Agencies involved in actions that will result in the control or structural modification of any natural stream or body of water for any purpose, to take action to protect the fish and wildlife resources that may be affected by the action.		Applicable	Location
Endangered Species Act (ESA)	7 USC 136 16 USC 460 16 USC 1531 et seq. 40 CFR 6.302 50 CFR 402	Federal Agencies are prohibited from jeopardizing threatened and endangered species or adversely modifying habitats essential to their survival. Requires consultation with the Service charged with protection the listed species.		Applicable	Location (habitat); Action (species)
Migratory Bird Treaty Act	16 USC 703 et seq.	Taking, killing, possessing migratory birds is unlawful.		Applicable	Action
Federal Land Policy and Management Act (FLPMA)	Public Law 94-579, 43 U.S.C, et. seq.) and the Mineral Leasing Act (30 U.S.C. § 181) in regulations at 43 CFR 3500, and	Contracts negotiated between the mine operators and the U.S. Department of the Interior. Lessee must carry on all operations in accordance with approved methods and practices as provided in the operating regulations, and the approved mining plans in a manner that		Applicable	Location

Statutes, Regulations, Standards, or Requirements [a]	Citations or References [b]	General Description	Site-Specific Comments	Potentially Applicable or Relevant and Appropriate or TBC	Chemical Location or Action-Specific
	specific terms and conditions as contained in the individual mineral leases and rights-of-way	minimizes adverse impacts to the land, air, and water, to cultural, biological, visual, minerals, and other resources, and to other land uses or users.			
Fort Bridger Treaty 1868	15 Stat 673	Established the Reservation as a "permanent home" for the signatory tribes. Established reserved off-reservation hunting, fishing and gathering rights to the tribes, these rights are exercised on public lands throughout the State of Idaho.		TBC	Location
Mineral Leasing Act	30 USC § 181 et seq., and 43 CFR 3500-3599	Regulates leasing, mining, processing and reclamation of federally owned phosphate deposits. Prevent unnecessary or undue degradation of public lands by operations authorized by the mining laws.		Applicable	Action
U.S. Bureau of Land Management Record of Decision and Pocatello Resource Management Plan (April 2012)	40 CFR 1508.27	To sustain the health, diversity, and productivity of the public lands. The plan provides objectives, land use allocations, and management direction to maintain, improve, or restore resource conditions and provide for the economic needs of local communities over the long term. The plan applies to BLM Managed public lands and split estate lands where minerals are federally owned in southeast Idaho.		Applicable	Action and Location
Mine and Reclamation Plans		Operation Plans that are approved subsequent to issuing the lease at a time after mining is proposed. Establish mine plans and reclamation requirements.		TBC	Location

Statutes, Regulations, Standards, or Requirements [a]	Citations or References [b]	General Description	Site-Specific Comments	Potentially Applicable or Relevant and Appropriate or TBC	Chemical Location or Action-Specific
Additional Potential Tribal ARARs					
Shoshone-Bannock Tribes Environmental Waste Management Program. Soil Cleanup Standards for Contaminated Properties, December 2, 2010.	Tribal Resolution ENVR-2011-0022 January 6, 2011	Soil Cleanup Standards for Contaminated Properties.	ARAR status depends on land ownership, and whether requirements are determined to be more stringent than federal requirements.	Tentatively Relevant and Appropriate	Chemical, and Action-specific
Additional Potential ARARs related to radioactive contaminants					
Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination	OSWER No. 9200.4-18, August 22, 1997	Clarifying guidance for establishing protective cleanup levels for radioactive contamination at CERCLA sites. Attachment A lists likely Federal ARARs for Superfund response actions.		TBC	
Performance objectives for the land disposal of low level radioactive waste (LLW).	10 CFR 61.41			Relevant and Appropriate	
National Emission Standards for Hazardous Air Pollutants (NESHAPs) under the Clean Air Act, that apply to radionuclides.	40 CFR 61 Subparts H and I			Relevant and Appropriate	

[a] Statutes and policies, and their citations, are provided as headings to identify general categories of potential ARARs for the convenience of the reader. Listing the statutes and policies does not indicate acceptance of the entire statutes or policies as potential ARARs; specific potential ARARs are addressed in the table below each general heading. Only substantive requirements of the specific citations are considered potential ARARs.

[b] Only the substantive provisions of the requirements cited in this table are potential ARARs

[c] The preamble to the NCP indicates that state regulations that are components of a federally authorized or delegated state program are generally considered federal requirements and potential federal ARARs for the purposes of ARARs analysis (55 Fed. Reg. 8666, 8742 [1990]).

APPENDIX C-3

P4 Responses to A/T Comments (dated May 15, 2015) on *P4's Ballard Mine Feasibility Study Report, Memorandum 1 – Site Background and Screening of Technologies, Draft Rev 0, March 2015*

Submitted to A/Ts on June 10, 2015

Leah Wolf Martin

From: Vance Drain <Vance.K.Drain@mwhglobal.com>
Sent: Wednesday, June 10, 2015 3:43 PM
To: Tomten, Dave; PRICKETT, MOLLY [AG/1850]; Bruce Narloch; Bruce Olenick; Cary Foulk (cfoulk@integrated-geosolutions.com); Celeste Christensen; Colleen O'Hara-Epperly; COOPER, RANDALL LEE [AG/1000]; Dennis Smith (dennis.smith2@ch2m.com); Eldine Stevens; Gary Billman; Jeff Cundick; Jeff Schut; jeffrey.fromm@deq.idaho.gov; Jeremy Moore (jeremy_n_moore@fws.gov); Wallace, Joe; Kelly Wright; Leah Wolf Martin (leah@wolfmartininc.com); LEATHERMAN, CHRIS R [AG/1850]; Edmond, Lorraine; Mary Kauffman; Michael Rowe; Randy Vranes; robert.blaesing@bia.gov; Sandi Fisher; Shephard, Burt; Stifelman, Marc; Stumbo, Sherri A -FS; susanh@ida.net; tamartin@sbtribes.com; Trina Burgin; Anthony Magliocchino; Michael Gronseth
Subject: P4 Responses to A/T Comments on Draft Ballard FS Memo #1(Rev 0)
Attachments: P4 RTCs compiled comments on FS TM1 (06-10-2015).docx; P4 RTCs compiled comments on FS TM1 (06-10-2015).pdf

Dear Dave et. al.,

In an attempt to keep the completion of the Ballard Feasibility Study TM#1 moving forward, we are providing responses to the A/T comment (RTCs). Embedded in the attached RTC document is an example single index plot depicting selenium concentrations both in the background formations and in upland soil samples collected throughout the Ballard Mine. Also the USL, UCLs, and other summary statistics are displayed on this index plot.

Please let us know if you have any questions or concerns regarding these RTCs, and we can discuss any issues you may have during the next bi-weekly call.

Best Regards,

Vance

PS Also note that responses to ARAR comments will be forthcoming.

P4's Responses to A/T Comments dated May 15, 2015

on the

Feasibility Study Technical Memorandum for P4's Ballard Mine Draft Revision 0, March 2015

General Comments

GC#1. Please revise terminology and use the term preliminary remediation goal (PRG) in the document rather than proposed cleanup level (PCL). Use of "PRG" mirrors the language in the NCP and is consistent with practice within EPA Region 10. In the Record of Decision phase, the "PRG" nomenclature (and sometimes the value itself) will be changed (and locked in) to the term "Cleanup Level" or "Remediation Goal."

> ***P4 Response (GC#1)**: At CERCLA sites, preliminary remediation goals (PRGs) typically are "specific statements of desired endpoint concentrations of risk levels (55 FR 8713, March 8, 1990) that are conservative, default endpoint concentrations used in screening and initial development of remedial alternatives before consideration of information from site specific risk assessments". In accordance with the NCP (see 40 CFR §300.430(e)(2)(i)(A)), PRGs are generally at the low end of the risk range and typically are used in screening and initial development of remedial alternatives before consideration of more detailed information from the site-specific risk assessment (OSWER 9200.3-56).*
>
> *Per DOE guidance on development of remediation goals (RGs) under CERCLA (DOE/EH-413/9711, 1997)), PRGs are typically based on the upper bound carcinogenic risk of one in a million (10-6) or a hazard quotient of one. PRGs can be proportionally adjusted upward to become RGs for a higher acceptable carcinogenic risk or hazard level to account for the conservatism inherent in the PRGs (i.e., toxicity values and exposure assumptions). Specifically, the RG can be based on a 10-4 cancer risk and still be within the NCP's acceptable range (10-4 to 10-6) for carcinogenic risk. Similarly, the RG for a noncarcinogen can be several times higher than the corresponding PRG based on the uncertainty factor associated with the reference dose and exposure factors. In the Ballard Mine RI Report (MWH, 2014), PRGs were used for nature and extent and risk assessment screening evaluations.*
>
> *In the Draft Ballard Mine FS Memo #1 (FS Memo #1), site-specific risk-based cleanup levels (RBCLs) were calculated for soil and sediment media using the same human and ecological receptors, exposure pathways and exposure assumptions that were used during the evaluations in the Ballard BRA included in the Ballard Mine RI Report. The human and ecological receptors with the highest risk (most conservative) for each COC and COEC were identified in the BRA. Then Site-specific RBCLs were calculated based on a target cancer risk of 1E-04 for human receptors, and a non-cancer HQ of 1.0 for human and ecological receptors. These RBCLs in addition to background values (BTVs) were used to develop the preliminary cleanup levels (PCLs).*

As discussed in GC #2 below, P4 is proposing to remove the additive approach in developing PCLs. The revised PCLs will be set at the higher of either the RBCL or BTV for each constituent in soil and sediment media. These values are not the same as PRGs, therefore P4 is proposing, as discussed during our call with you on June 1, 2015, to continue referring to these values PCLs because of where we are in the CERCLA process. Based on your comment, P4 will include text to clarify that "the PCLs will not be final until the Record of Decision (ROD)".

GC#2. In draft Tech Memo #1, P4 proposed establishing soil PRGs = RBCL+BTV. This approach is a non-starter as it would set soil PRGs above upper threshold levels of the background data set, and because there is no support for this approach in policy or guidance. See also specific comments on this approach below. For soil, the methodology for establishing PRGs is a typically a step-by-step process involving first calculating concentrations of COCs in soil at an acceptable risk level (RBCLs), and then modifying the risk-based levels by considering ARARs, target risk range for various receptors, technical limitations, uncertainty, and other factors including background. There is no rigid formula for this analysis, and the process must consider a variety of factors to achieve risk management goals. In this case, because RBCLs are low relative to background, consideration of background will be a key driver in establishing soil PRGs.

At this point, based on the information provided, the A / T is not prepared to provide specific direction on a methodology for establishing soil PRGs. To advance this issue toward resolution, we believe it would be appropriate to consider some additional information or graphical presentation of existing information.

Specifically, we are requesting:

- RBCLs for all COCs for other human health exposure scenarios (in addition to residential scenario), and for all ecological receptors (in addition to the most sensitive).
- Index plots of key COCs grouped by subpopulations with potential decision statistics displayed.
- Summary table reporting USLs, UPL, and UTLs for various COCs to illustrate differences.
- A description of how soil PRGs would be applied using the amount and type of data available to make cleanup decisions, in terms of decision rules.

This information will provide additional insight that will allow for more informed and balanced risk management decisions. Proposed decision rules regarding application of PRGs will need to consider the potential for uptake by veg over an appropriate soil depth and consider how variability over a source area (including presence of hot spots) would be handled.

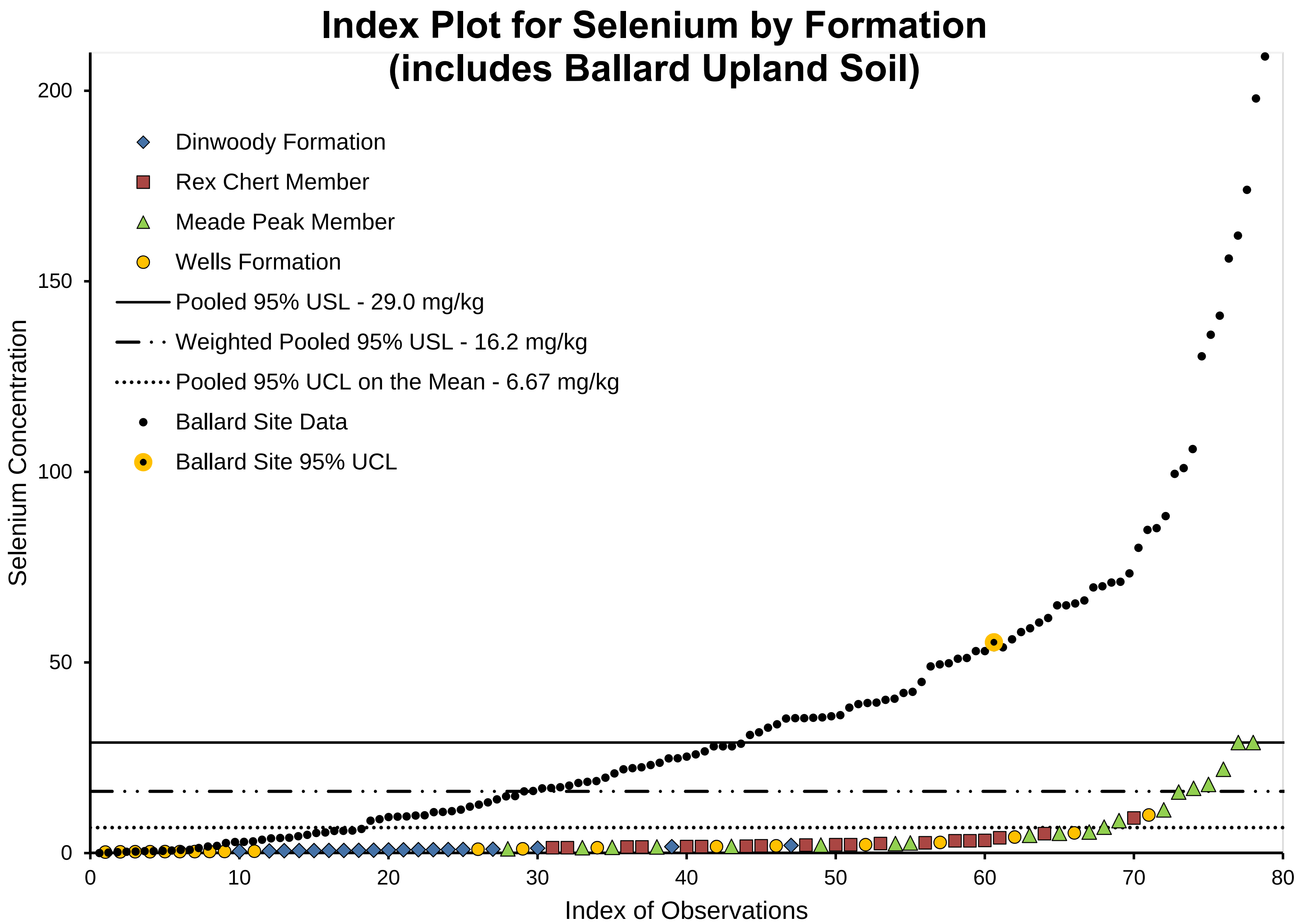
***P4 Response (GC#2)**: Based on the A/T comment, P4 is proposing that preliminary cleanup levels for purpose of evaluating alternatives in the FS are based on the higher of the lowest RBCL or background value.*

Bullet #1: The soil RBCLs in the current memorandum are based on the most conservative receptor and, and the lowest soil RBCL for a given COC/COEC is typically lower than background. As a result, PCLs for most of the COCs/ROCs are based on background values. P4 proposes to calculate soil RBCLs only for key human health receptors (i.e., seasonal rancher, recreational hunter and camper/hiker) and for key COCs/ROCs.

Bullet #2: Agreed. P4 will provide index plots for a few key soil COCs/ROCs/COECs, as described in the e-mail from Dave Tomten to Molly Prickett, dated June 3, 2015. An example is provided on the next page.

Bullet #3: Agreed. A summary table comparing statistical parameters (e.g., USLs, UTLs, and UCLs) for metals concentrations in upland background soil will be provided.

Bullet #4: Details of the anticipated confirmation sampling program (e.g., how soil sample and other data collected during the RA will be evaluated against the ROD-approved cleanup levels) typically are defined during the preparation of in the RA Work Plan (following approval of the Final Remedial Design). Therefore, we believe it is premature to define "possible" decision rules before the Site remedy is selected and the appropriate decision rules can be defined based on the Selected Remedy.


Index Plot for Selenium by Formation
(includes Ballard Upland Soil)
Dinwoody Formation
Rex Chert Member
Meade Peak Member
Wells Formation
Pooled 95% USL - 29.0 mg/kg
Weighted Pooled 95% USL - 16.2 mg/kg
Pooled 95% UCL on the Mean - 6.67 mg/kg
Ballard Site Data
Ballard Site 95% UCL
Selenium Concentration
Index of Observations
0
50
100
150
200
0
10
20
30
40
50
60
70
80

GC#3. Revise TM#1 to fully incorporate results from the Tier I Ballard Mine Radiological Risk Calculations, which showed that risks to humans are driven by Radium. In addition, the next version of TM#1 should present RBCLs and proposed PRGs for radiological COCs.

> ***P4 Response (GC#3)****: Agreed. FS Memo #1 will be revised to include a description of the results and a summary table of Tables 2 through 5 from the Final Ballard Mine Baseline Risk Assessment Addendum (February 2015). The next version of the FS Memo #1 will also present RBCLs and PCLs for radionuclides of concern (ROCs).*

GC#4. There are various statements throughout the document regarding potential bias in the background soil data set. The next version of TM should be revised to include the new provisional background soil data and summary statistics, with a note that the background report is not yet final. Inclusion of this information eliminates the need to speculate regarding bias. Please delete speculative statements regarding potential bias.

> ***P4 Response (GC#4)****: Agreed. FS Memo #1 text will be revised to remove statements regarding potential bias in the background datasets and reference results from the 2014 radiological and background investigation, as applicable. FS Memo #1 also will be revised to include the provisional background upland soil results for the 95% USL and the previous background levels will be removed from Table 3-7. The summary statistics (95% UCL, 95% USL, and 95% UTL) for background soils will be included the Radiological/Background Report.*

GC#5. Considering empirical radiological data were obtained in 2014, the speculative statements about modeling from uranium and background radionuclide levels need to be removed from subsequent drafts of the FS memoranda, and replaced with discussion comparing findings from 2014 characterization work with results from secular equilibrium modeling.

> ***P4 Response (GC#5)****: Agreed. FS Memo #1 will be revised to remove statement regarding the uncertainty pertaining to background concentration and risk estimates for uranium based on secular equilibrium modeling. The revised memo also will include a discussion of the 2014 characterization work and a qualitative/semi-quantitative comparison of risk estimates based on the 2014 data and secular equilibrium modeling.*

GC#6. Where Vegetation is considered a secondary media, it should be discussed how the remedial technologies will impact COC / COEC levels in vegetation.

> ***P4 Response (GC#6)****: FS Memo #1 will be revised to include a discussion of how remedial technologies will impact COC/COEC levels in vegetation.*

GC#7. We note that the Area-Wide study (IDEQ 2001) is only mentioned in historical references, and the RI appropriately relied primarily on site specific information. Please note that Tribes have requested that data from the study not be used.

P4 Response (GC#7)*: Comment noted. Results of the Area-Wide study have been historically referenced and will be used in future documents for only comparative purposes during the RI/FS process.*

GC#8. ARARs – In the interest of getting comments out on TM#1, these comments include only limited comments on ARARs. The A / T intend to provide additional comments on potential ARARs in the coming weeks, as potential ARARs are identified and compiled. We anticipate that comments will be provided within the next two weeks.

P4 Response (GC#8)*: Comment noted. Additional comments on ARARs will be incorporated into the revised FS Memo #1.*

<u>Specific Comments</u>

SC-1 **TOC.** Add list of appendices and an Acronyms and Abbreviations section to the Table of Contents.

P4 Response (SC-1): *FS Memo #1 will be revised to include the list of appendices and the acronyms and abbreviation section.*

SC-2 **1.1.** Both the BLM and the US Fish and Wildlife Service are in the Department of Interior. Please correct the paragraph to make this fact more explicit.

P4 Response (SC-2): *FS Memo #1 will be revised to clarify that both the BLM and US Fish and Wildlife Service are in the Department of Interior.*

SC-3 **1.2.** Delete the second "for each."

P4 Response (SC-3)*: The text will be revised per the comment.*

SC-4 **1.3.1.** Suggest moving discussion of risks and future land uses at the Shop Area to 2.3.1. (Starting with "The Ballard Shop was investigated…." through end of section 1.3.1.)

P4 Response (SC-4)*: The details of the Ballard Shop Area in Section 1.3.1 will be incorporated in Section 2.3.1. However, text will be included in Section 1.3.1 to state that the Ballard Shop will be addressed in the future and reference that additional details regarding the Ballard Shop Area are provided in Section 2.3.1.*

SC-5 **1.3.2.** Revise to clarify that Monsanto (not P4) owned and operated the plant and mine during the operational phase of the project.

P4 Response (SC-5)*: The text will be revised per the comment.*

SC-6 **1.4.** Delete "and" to read "(5) geology, (6) hydrogeology."

P4 Response (SC-6)*: The text will be revised per the comment.*

SC-7 **1.4.6.** Insert "and" to read "generally unconfined and may interact."

***P4 Response (SC-7)**: The text will be revised per the comment.*

SC-8 **1.4.6.** Change to "Dinwoody Formation."

***P4 Response (SC-8)**: The text will be revised per the comment.*

SC-9 **1.4.7.** Please visit the Idaho Fish and Wildlife Office web site to access the most current Endangered Species information (http: / / www.fws.gov / idaho / species / IdahoSpeciesList081414.pdf). Only Canada lynx are Federally listed in Caribou County; the greater sage-grouse are a candidate species.

***P4 Response (SC-9)**: The text will be revised per the comment.*

SC-10 **1.4.8.** The land use section provides a general discussion on uses around the area, however more specifics on adjacent ranch properties (where site-related contamination is known to have migrated) should be added. In addition, add language describing the potential for use of Site by Tribes, such as: "the Ballard Mine is located in the vicinity of federal lands where there are tribal cultural activities, specifically hunting and gathering." Also revise to indicate that the scattered ranches and farms in the area use groundwater for domestic use.

***P4 Response (SC-10)**: Text in Section 1.4.8 will be revised to clarify the land use of adjacent ranch properties. Also, to be consistent with Section 2.9 of the Ballard Mine RI Report, the text will also include the following: "In the valleys surrounding the mined areas, groundwater is primarily used for livestock watering, limited domestic use, and mine site water supply."*

SC-11 **2.1.** In various places in section 2.1 the narrative refers to "screening levels" for various media. To assist reader, please define at first usage to avoid potential confusion.

***P4 Response (SC-11)**: The first usage of screening levels in Section 2.1 will be further defined and reference the screening levels used in the Ballard Mine RI Report.*

SC-12 **2.1.** Reword as the sentence reads awkwardly especially "…leading from the Site as shallow groundwater plumes leading from the source area."

***P4 Response (SC-12)**: The sentence will be revised as follows: "Water can continue downward through the mine dump, infiltrate into the underlying shallow groundwater and then appear as seeps in the stream channels leading from the Site or as shallow groundwater plumes leading from the source area."*

SC-13 **2.1.1.** First sentence – "Concentrations of most constituents in the upland soil samples collected across waste rock dumps, mine pit backfill, and the haul road are elevated above screening and background levels, for several metals / metalloids.": State what the screening level is and its basis and the range that the COCs are above the screening and background levels. This comment also pertains to other media that describe sample results above screening / background levels.

P4 Response (SC-13)*: The nature and extent of contamination and comparison of Site concentrations to screening levels are completely detailed for each medium in Section 4.0 of the Ballard Mine RI Report. The objective of Section 2.1 of FS Memo #1 is to present a high-level summary of the nature and extent for each medium. A reference to applicable sections within the Ballard Mine RI Report will be included in Section 2.1 for each of the various media.*

SC-14 **2.1.** Note presence of radiogenic elements in the waste materials, and associated nature and extent of daughters including radon gas and gamma.

P4 Response (SC-14)*: All sections of the FS Memo #1 will be revised, as necessary, to include a discussion of ROCs.*

SC-15 **2.1.** The "key findings" of the nature and extent of contamination needs to also describe whether contamination has migrated off the mined areas and off the P4 property.

P4 Response (SC-15)*: For several of the medium-specific summaries in Section 2.1, a sentence or two is included that describes downstream (i.e., off of P4 property) conditions. However, it will be further clarified where impacts extend off of the P4 property.*

SC-16 **2.1.2.** The vegetation discussion should describe the presence and abundance of selenium accumulator and hyperaccumulator species.

P4 Response (SC-16)*: A summary of hyperaccumulator presence and abundance will be added to Section 2.1.2.*

SC-17 **2.1.4.** Delete "the" to read "and other constituents."

P4 Response (SC-17)*: The text will be revised per the comment.*

SC-18 **2.1.5.** Change to ". (i.e., exceed levels in a single event at a single location, exceed in a very few locations [e.g., dump seeps], or exceed in total but not dissolved fractions)."

P4 Response (SC-18)*: The text will be revised per the comment.*

SC-19 **2.2.** This paragraph describes two scenarios within the conceptual site models of where waste rock is placed but does not state the impact of these two waste placement locations and how this influences the fate and transport of CoCs for each scenario. Please add this discussion.

P4 Response (SC-19)*: A discussion of impacts due to waste placement locations will be included in Section 2.2.*

SC-20 **2.3.1.** First sentence states that "conservative" assumptions were made with respect to the HHRA. Either describe how the assumptions were conservative, or refer to subsequent discussions where the conservativeness is discussed, or delete if the conservativeness of assumptions cannot be described and documented.

***P4 Response (SC-20)**: The text will be revised to replace the term "conservative assumptions" with "reasonable maximum exposure (RME) assumptions".*

SC-21 **2.3.1.** Considering ranching is a current use on areas where contamination is known to be present, it is unclear why this exposure scenario is considered only as a future use. The current and future land use descriptions in this section are not consistent with the descriptions in the RI and are not consistent with the scenarios considered in the risk assessment (RA). All scenarios evaluated in the RA were considered to be both current and future use with the exception of the hypothetical future residential scenario. The FS memo needs to be revised to accurately reflect the current uses and those evaluated in the RA.

***P4 Response (SC-21)**: Livestock grazing is not a current land use on the Ballard Mine, proper. However, livestock grazing occurs adjacent to the Ballard Mine and is a potential future land use on the Ballard Site; therefore, potential risks to future livestock and seasonal ranchers were evaluated in the Ballard RI/BRA Report. Paragraph 1 of Section 2.3.1 will be revised to clarify the current and future land uses on the Ballard Mine~~, proper~~ (i.e., the disturbed area) and the Ballard CERCLA Site (i.e., the area impacted by the Ballard Site).*

SC-22 **2.3.1.** Human health risks are presented by medium only, which does not accurately reflect the total exposure to potential receptors. Cumulative risks from exposure to all media were provided in the RA and need to be summarized in the FS.

***P4 Response (SC-22)**: Agreed. Cumulative risks will be incorporated into Table 2-1.*

SC-23 **2.3.1.** Replace "likely to be overestimated" with "may be." Also delete (2) as background concentrations will not change site risks.

***P4 Response (SC-23)**: The reference to "likely to be overestimated" in regard to radiological risk estimates based on sequential decay modeling from total uranium concentrations will be deleted. Please note that background concentrations may affect both the background and incremental risk estimates depending on how the 2014 background concentrations compare to previous background results. However, now that Site radiological data and new background data for metals and radionuclides have been collected for COCs/ROCs in upland soils in 2014, Section 2.3.1 will be revised to include a discussion of these results and their potential effect on previous risk estimates.*

SC-24 **2.3.1.** Here and elsewhere, define, and use care in, use of the terms Site and Mine Area. Note that the Site includes mine features such as pits and dumps, and the Site would include all areas where contaminants have come to be located. Thus the Site would include land near the mine features that are impacted by surface water runoff, or include plumes of contaminated groundwater. Consistent with this direction, delete language on page 2-7 indicating that future subsistence, ranching and residential uses are unlikely to occur in the future. Seasonal ranching is a known current use, and subsistence and residential (farm or ranch on the Site) are reasonably foreseeable at least for some portions of the Site. In addition, delete or revise final sentence of 2.3.1 as it may be necessary to control future uses of some areas downgradient of the mine dumps for some period of time (e.g., east side of Ballard) due to risks associated with releases of contaminants to GW and SW.

***P4 Response (SC-24)**: The text in Section 2.3.1 will be clarified to differentiate uses on the Ballard Mine (the disturbed mine areas that are ~~P4-controlled property~~owned by P4 and State leased lands) versus the Ballard CERCLA Site area (includes impacted off-mine areas) and the different current and future land uses both on the Ballard Mine and on the Ballard Site areas. For example, the first sentence on Page 2-7 will be revised as follows: "It should be noted that grazing and recreational activities, such as hunting, camping and hiking, on the Ballard Mine including leased State lands (i.e., the disturbed area) are most representative of the current land uses possible at the Ballard Mine. Grazing and recreational activities also are the most likely future land uses for the Ballard Mine."*

In addition, as a result of the substantially decreased COC/COEC concentrations downstream of the Ballard Mine~~, proper~~ (i.e., the disturbed area), the last sentence accurately describes Site impacts downstream of the mine area. But an additional sentence will be added as follows: "However, as discussed in this memorandum, remedial options will be evaluated for both the disturbed mine footprint and potentially impacted lands in the vicinity of the mine (i.e., Ballard CERCLA Site boundary)."~~However, as discussed in this memorandum, remedial options will be evaluated for both the Ballard Mine and potentially impacted lands adjacent to the mine (Ballard Site).~~

SC-25 **2.3.1.** The FS memo states that, "The Native American, hypothetical future resident, and seasonal rancher were evaluated to determine if land use controls and / or remediation are required to protect future subsistence, residential or seasonal ranching land uses…" Some of these are current use scenarios (e.g., on-site grazing of cattle) and there is offsite contamination on private lands currently used for ranching. The FS memo needs to be revised to accurately describe the current uses within the extent of contamination and the risks to these users.

***P4 Response (SC-25)**: Please see P4's response to SC-24.*

SC-26 **2.3.2.** First usage of "HQ" – spell out

***P4 Response (SC-26)**: The text will be revised per the comment.*

SC-27 **2.3.2.** The FS memo indicates that "based on the changes to the revised background data set, it may be necessary to recalculated ecological HQ estimates." Site risks will not be impacted by the new background data. Instead, recalculation of the background risk may be useful to help risk managers understand the risk attributable to background.

Include paragraph noting that eco risks were estimated using the data collected, which did not include collection of plants known to hyper-accumulate selenium. Add language explicitly acknowledging that plants that hyper-accumulate Se are known to be present in some nearby mining disturbed areas, and these facts contribute uncertainty to risk estimates. Because such plants are known to be present in mining disturbed areas, there may be additional risks associated with acute exposure scenarios for hot spots. These risks are not reflected in risk estimates. Ditto for section 2.3.3 for livestock.

***P4 Response (SC-27)**: Please note that background concentrations may affect both background and incremental risk estimates. However, now that new background data were collected in 2014 for COCs in upland soils, Section 2.3.2 will be revised to present these results and their potential effect on previous risk estimates.*

Text will be revised to acknowledge that the ecological and livestock risk assessments did not take into account the potentially higher selenium concentrations that may occur in hyperaccumulator plant species. However, please note that P4 has an active hyperaccumulator plant eradication program at the P4 Mine Sites and actually has never observed hyperaccumulators at the Ballard Mine. Consequently, the ecological and livestock risk estimates presented in the Ballard Mine RI/BRA reflect current conditions.

SC-28 **2.3.3.** Note that horses may have been known to graze at some Sites in the mining district. Revise to clarify that while grazing is not currently allowed on lands controlled by P4, there are portions of the Site below the dumps where seasonal grazing is a known current land use.

***P4 Response (SC-28)**: Agreed. The text will be revised to acknowledge that grazing of horses has been documented in the vicinity of the Ballard Mine area.*

SC-29 **2.3.4.** The statement for excluding thallium as a COC seems unsubstantiated. Please state basis of exclusion —- (i.e., only detected once in X samples, or similar).

***P4 Response (SC-29)**: The text in Section 2.3.4 will be revised to explain that only one sample out of 19 samples that were analyzed for thallium in groundwater, exceeded the screening level of 0.00016 mg/L (USEPA RSL for tap water). The sample was collected from MMW020 in 2007 and was reported at 0.00~~0~~11 mg/L. The text will also be revised to note that the MCL for thallium is 0.002 mg/L.*

SC-30 **2.4.1.** Add "manganese" to this list based on the first sentence in the next paragraph.

***P4 Response (SC-30)**: The text will be revised to include manganese.*

SC-31 **Table 2-1.** Include summary information on radiological risk, or add new table.

***P4 Response (SC-31)**: A new summary table of Tier 1 radiological risks will be added and referenced in Section 2.3.1. In addition, a discussion of the effects of the 2014 radiological background and ~~radiological~~Site- data will be included and compared to the Tier 1 radiological risks presented in the Ballard Mine BRA.*

SC-32 **Table 2-1.** Total cumulative risk for each receptor (exposure scenario) should be provided.

***P4 Response (SC-32)**: Total cumulative risks for each receptor (exposure scenario) will be provided in Table 2-1.~~ or a new summary Table in Section 2.0~~.*

SC-33 **Table 2-1.** The incremental HI for culturally significant plants in upland soils appears to be incorrectly calculated. A revise to the HI is necessary.

***P4 Response (SC-33)**: Please note that the cumulative incremental hazard estimate for culturally significant plants grown in upland soil presented in Table 2-1 is the sum of the chemical-specific difference between the Site HQ and the background HQ, where if the chemical-specific background HQ exceeds the chemical-specific Site HQ, the incremental HQ for that chemical is equal to zero. The primary noncancer risk drivers for Site upland culturally significant plants (antimony, selenium, and uranium) were different than the primary noncancer risk drivers for background upland culturally significant plants (arsenic, cobalt, manganese, and thallium). Because the largest HQs comprising the HI for Site, upland culturally significant plants, are associated with different metals than those associated with the largest HQs comprising the HI for background, upland culturally significant plants, the incremental HI is not similar to the difference between the Site and background HIs.*

SC-34 **Table 2-1.** The use of footnote d is confusing and appears to be in error. Footnote d apparently indicates dissolved contaminant levels were used, however this footnote is used for sediment which is nonsensical. This footnote is also used for cattle-surface water. Unlike protection of fish, which often uses dissolved levels for comparisons with water quality criteria, cattle would be exposed to total metals concentrations. Revisions to the table are necessary.

***P4 Response (SC-34)**: Footnote d will be removed from the "Aquatic Plant - Sediment" row of Table 2-1. Although aquatic plants were evaluated for surface water COPCs, as described in the BRA, all plant tissue concentrations were based on sediment concentrations and sediment uptake factors due to uncertainty associated with surface water uptake factors.*

The use of dissolved, rather than total, metals concentration to model cattle and upper trophic level ecological surface water ingestion is consistent with the approach used in the approved Human Health and Ecological Risk Assessment Work Plan (MWH, 2011) Ballard Mine BRA (MWH, 2014), as well as the plan for long-term monitoring since 2009. The approved 2009 and 2010 Surface Water Monitoring Sampling and Analysis Plan (MWH, 2009) stated that dissolved or total metals will be used in surface water depending upon the form of the metal serving as the basis for the screening standard (i.e., the dissolved fraction for all analytes except selenium).

SC-35 **Table 2-4.** Revise table or include additional table to reflect radiological COCs.

***P4 Response (SC-35)**: Tables 2-4 and 2-7 will be revised to include ROCs.*

SC-36 **Drawing 2-2.** Does this drawing also include co-located sediment sample locations? Revise accordingly.

***P4 Response (SC-36)**: This drawing shows the station locations for surface water, sediment and riparian soil. It does not show the exact sample locations. For example, during the 2010 supplemental sediment and riparian soil sampling, up to five sediment locations may have been collected from select pond and stream stations. The location of these samples on Drawing 2-2 is not necessary given that Section 2.0 of FS Memo #1 is a summary of the nature and extent of contamination at the Ballard Site. Also, the exact location of these samples would not be distinguished given the scale of the drawing. No revisions to Drawing 2-2 are necessary.*

SC-37 **3.0.** Beginning with the title of Section 3.0 and throughout the rest of the document: Please revise terminology and use the term preliminary remediation goal (PRG) at this stage of the process, rather than "proposed cleanup level". Use of "PRG" mirrors the language in the NCP and is consistent with practice within EPA Region 10. In the Record of Decision phase, the "PRG" nomenclature (and sometimes the value itself) will be changed (and locked in) to the term "Cleanup Level". Use of the term RBCL is useful and helps to clarify stepwise process for developing candidate PRGs.

***P4 Response (SC-37)**: Please see P4's response to GC#1.*

SC-38 **3.1.** Clarify that the list of potential ARARs provided is preliminary. ARARs are selected and finalized in the ROD. This process will also allow for further discussion and evaluation of the relevancy and appropriateness of some potential ARARs using the factors in 40 CFR 300.400(g)(2).

***P4 Response (SC-38)**: Section 3.1 will be revised to clarify that the list of potential ARARs are preliminary and will be finalized in the ROD.*

SC-39 **3.2.1.** Please provide citation to support final sentence of this section. Note that language regarding consistency of application applies to state ARARs.

***P4 Response (SC-39)**: The final sentence in Section 3.2.1 will include the reference (USEPA, 1988b) below and will be included in Section 6.0 References. In addition, the current USEPA, 1988 reference will be changed to USEPA, 1988a.*

USEPA, 1988b. CERCLA Compliance with Other Law Manual: Interim Final. EPA/540/G-89/006. August 1988.

SC-40 **3.4.** Section 2.2 identified the contaminant pathway between surface water and groundwater. Considering this contaminant transport mechanism occurring at the site, it seems appropriate to include "Hydraulic Isolation" as a General Response Action (i.e., remedial measures to minimize the transport of contaminants from surface water to groundwater and vis versa.). Although it appears this concept may be partially captured under Containment (Sediment Control Basins) in Surface Water Table 4-4 and under Containment (Vertical Barriers) in Groundwater Table 4-6.

***P4 Response (SC-40)**: The current pathway for contaminated surface water to groundwater is infiltration along the ephemeral drainages emanating from the Ballard Mine. For a portion of the year when the shallow water table is elevated, groundwater actually may be discharge to surface water along the channels, but during the drier portions of the year, water in the channels either evaporates or infiltrates.*

Only one technology, channel lining, is potentially appropriate and applicable for isolating surface water from groundwater at the Site. Lining would greatly reduce infiltration to groundwater, but in effect would just transfer the contamination further downstream. For example, spring and seep flows currently does not reach the Blackfoot River for most of the year. These flows could reach the Blackfoot River with channel lining (if they did not evaporate first). For this reason, surface water isolation was not considered, with the exception of pond lining. Pond lining, along with the lining of wetlands and other similar features, would be a design element of these alternatives opposed to a standalone alternative.

An additional consideration is that most alternatives for Site remediation include source control as a primary component. Source control addresses either direct or indirect surface water contamination at the Site and effectively eliminates it, which addresses downstream infiltration of surface water to groundwater. If source controls are in place, clean surface water will infiltrate into the shallow groundwater and assist with shallow groundwater remediation.

Based on these considerations, the text will not be revised.

SC-41 **Table 3-3.** Federal Location-Specific ARARs: The Bevill-exemption of mining wastes should be specifically identified and summarized in the ARARs tables. The Bevill exemption to RCRA provides an exemption of mining wastes as hazardous wastes (Subtitle C), but the mining wastes are still classified as RCRA solid wastes (Subtitle D). This is an important determination when addressing mine waste piles or treatment stream wastes.

***P4 Response (SC-41)**: The Bevill-exemption of mining wastes will be added to Table 3-3.*

SC-42 **Table 3-3.** Please add the Federal Migratory Bird Treaty Act to this table, as it is an ARAR at the Site.

***P4 Response (SC-42)**: The Federal Migratory Bird Treaty Act will be added to Table 3-3.*

SC-43 **3.5.** Last two sentences stating process of modifying Preliminary Cleanup Levels (aka PRGs): In this discussion it should be explained that it is at the ROD phase when the PCLs become set (legally binding) as cleanup levels.

***P4 Response (SC-43)**: Please see P4's response to GC#1. The process of finalizing the cleanup levels in the ROD phase will be added to Section 3.5.*

SC-44 **3.5.** The sentence states that "Vegetation is a secondary medium and adverse effects to this medium will be addressed through cleanup of primary medium (soils and sediment)…" To prove that the primary medium is effective at isolating COECs from receptors and meeting RAOs, it is recommended that corresponding concentrations of Se and other COECs in vegetation be calculated and utilized as performance targets. This information may aid in evaluating the effectiveness of remedial actions taken. In addition, the ability of a remedy to meet soil RAOs will depend on the selected PCLs (PRG) for soil, as well as design considerations that account for rooting depth of reclamation vegetation and perhaps other factors. The alternatives developed in TM#2 will need adequate detail and definition regarding soil remedies (thickness of cover profile for example) to evaluate effectiveness, costs and other criteria.

***P4 Response (SC-44)**: P4 agrees that performance targets for some secondary media, including upland vegetation, may be necessary to demonstrate that remediation of primary media will effectively achieve all RAOs. We are proposing to provide potential published sources of performance targets for vegetation in FS Memo #1 in Section 3.5. In the future, P4 may propose that site-specific COC/ROC performance targets be developed in vegetation based on collection and/or further evaluation of background vegetation data that is inclusive of all the P4 Sites geologic units (e.g., Meade Peak and Rex Chert Formations).*

SC-45 **3.5.** RBCLs (for arsenic) were calculated and reported at a target cancer risk of 10^{-4}, which exceeds Idaho DEQ's target risk of 10^{-5} and the EPA 10^{-6} "point of departure" in the stepwise process for establishing PRGs. For carcinogens, RBCLs should be presented for a range of risk levels within the DEQ and EPA target risk range, including 10^{-4} 10^{-5} and 10^{-6} to provide clarity and transparency to the process of establishing PRGs. The RBCLs may be revised from the point of departure by considering ARARs, uncertainty, background and other factors during subsequent steps in the development of PRGs.

***P4 Response (SC-45)**: Agreed. Please note that the only carcinogenic COCs/ROCs identified are arsenic and radium-226. RBCLs for this COC and ROC will be presented based on target cancer risk levels of 10^{-6}, 10^{-5} and 10^{-4}.*

SC-46 **3.5.** Calculating preliminary cleanup levels for soil or sediment for a given COC / COEC by adding background concentrations (upper threshold values) and the lowest risk based screening level together would not appear to protect resident receptors from toxicological effects. This observation is based on the fact that if chemical concentrations in soil and sediment exceed a RBCL because background is added to the RBCL, the receptor for which the PCL was derived would potentially be exposed to a COC / COEC above a given toxicity value. Thus, by nature, the proposed PCLs are not conservative in that they would appear to be permitting some level of risk to sensitive receptors exposed to Site media. Despite the cited cases (in the document) in which this methodology (PCL=background + RBCL) was used, it does not appear to be adequately protective of receptors in cases where both background and RBCLs are exceeded. Also note that in the FMC example cited, that an estimate of central tendency was used as a starting point. Thus the proposed additive approach using a USL as a starting point is unacceptable. See also general comments on use of background in establishing PRGs.

P4 Response (SC-46)*: PCLs will be based on the higher of the most conservative receptor RBCL and background as discussed in P4’s response to GC#2. However, please note that at the FMC site, the background values were an estimate of the 95% UCL on the mean concentration rather than an estimate of central tendency.*

SC-47 **3.5.** Section 3.5 describes the PRGs / PCLs as levels that are based on site-specific risk based cleanup levels protective of human and ecological receptors. Then, PCLs are described as a summation of the risk based cleanup level and background. Therefore, the PCLs are above levels that are protective of humans and ecological populations. The summation of the estimated upper range of background with risk based levels is not appropriate. For example, the proposed PCL for upland soil is equivalent to a LOAEL-based hazard quotient of 4.

P4 Response (SC-47)*: PCLs will be based on the higher of the most conservative receptor RBCL and background as discussed in P4’s response to GC#2.*

SC-48 **Table 3-5.** The RAOs must be revised to reflect program management expectations articulated in the NCP (40 CFR §430(a)(1)(iii)) and to be protective and definitive for all relevant exposure pathways. The FMC Plant OU ROD provides a good example of acceptable detail for description for some RAOs:

1. Prevent human exposure via all potential exposure pathways (external gamma radiation exposure, inhalation of radon in potential future buildings, incidental soil ingestion, dermal absorption, and fugitive dust inhalation, ingestion of fruit and vegetables) associated with soils and solids contaminated with COCs thereby resulting in an unacceptable risk to human health assuming current or reasonably anticipated future land use

2. Prevent potential ingestion of groundwater containing COCs in concentrations exceeding risk-based concentrations (RBC) or ARARs, or site-specific background concentrations if RBCs or ARARs are more stringent than background

3. Reduce the release and migration of COCs to the groundwater from BALLARD MINE sources resulting in concentrations in groundwater exceeding RBCs or ARARs, or site-specific background if RBCs or ARARs are more stringent than background

4. Restore groundwater that has been impacted by the Facility to meet RBCs or ARARs for COCs, or site-specific background levels if RBCs or ARARs are more stringent than background

5. Reduce the release and migration of COCs to surface water from BALLARD MINE sources at concentrations exceeding RBCs or ARARs, including water quality criteria pursuant to Sections 303 and 304 of the Clean Water Act.

6. Thus, please review the RAOs in Table 3-5 and revise as needed to reflect a similar level of detail. In particular, RAOs groundwater and surface water focus on preventing or reducing exposure. These should be revised to include explicit statements that groundwater and surface waters shall meet ARARs to the extent practicable. In addition, RAO for mine waste rock / soil for protection of eco receptors should reference uptake by vegetation and consumption by eco receptors.

***P4 Response (SC-48)**: The RAOs in Table 3-5 will be revised using the FMC RAOs as an example.*

SC-49 **Table 3-5.** Delete reference to livestock health from the RAOs due to unresolved policy questions regarding whether it is appropriate to trigger action or base remedy selection decisions on protection of livestock. Because protection of livestock is an important concern of stakeholders, it would be appropriate to evaluate and disclose information on whether the alternatives are protective of livestock.

***P4 Response (SC-49)**: The RAOs as proposed above will be revised to remove the reference to livestock. However, the protection of livestock will be considered in the FS technology and alternative evaluations.*

SC-50 **Table 3-5.** What are “acceptable risk levels” in vegetation and what standards for human health and environment determine it’s acceptable?

***P4 Response (SC-50)**: Please see P4’s response to SC-44.*

SC-51 **3.5.** The PRG / PCL discussion incorrectly cites the FMC Plant OU to support a Risk + Background level approach. FMC utilized a Risk + Background approach, but only for radium; not for metals or other constituents. FMC also used a central tendency estimate of background, which is not comparable the proposed 95% USL (upper simultaneous limit). Because background was estimated as a central tendency, it was necessary to add a risk increment to delineate background in the field. The sum of the central tendency background estimate and a 10^{-4} cancer risk based level is significantly less than the sum of the 95% USL and 10^{-4} cancer risk based level and is likely less than the 95% USL (without the additional risk increment).

***P4 Response (SC-51)**: PCLs will be based on the higher of the most conservative receptor RBCL and background as discussed in P4's response to GC#2. However, please note that at the FMC site, the background values were an estimate of the 95% UCL on the mean concentration rather than an estimate of central tendency.*

SC-52 **Table 3-7.** Assuming the radiological data collected in 2014 also show unacceptable risk from radium, PRGs / PCLs for radiological elements will need to be added to subsequent drafts of the FS documents.

***P4 Response (SC-52)**: Agreed. A discussion of the risk estimates associated with ROCs will be included in the revised FS Memo #1.*

SC-53 **Table 3-7.** Suggest replacing the ND for molybdenum in sediment with a < (detection limit); this may provide the risk manager with some indication of the potential contribution of background.

***P4 Response (SC-53)**: Table 3-7 will be revised as recommended in the comment.*

SC-54 **Table 3-7.** Suggest Changing "Media" in first column to "Primary Media" because vegetation is not put on these tables since it is considered secondary.

***P4 Response (SC-54)**: Table 3-7 will be revised as recommended in the comment.*

SC-55 **Table 3-7.** RBCLs for Uranium should be recalculated using a revised RfD, due to severe problems with the IRIS profile (it used a 1949 study that would no longer be considered adequate). I'm now recommending the 2013 ATSDR, subchronic, oral MRL (http://www.atsdr.cdc.gov/toxprofiles/tp.asp?id=440&tid=77). It's better supported than the MCL-RfD or the IRIS value, despite being subchronic. If necessary, we could convene a meeting of a subgroup of subject experts to further discuss this matter.

***P4 Response (SC-55)**: As per the e-mail from Dave Tomten to Molly Prickett, dated June 3, 2015, the RfD for uranium that was used to calculate human health RBCLs for uranium in FS TM#1 should be retained. The A/Ts may revise the recommended RfD in the future for use at other P4 sites.*

SC-56 **4.1.1 and 4.2.1.** Include paragraph noting that eco risks were estimated using the data collected, which did not include collection of plants known to hyper-accumulate selenium and that this is a source of uncertainty. Because such plants are known to be present in mining disturbed areas, there may be additional risks associated with acute exposure scenarios where receptors may ingest selenium hyper-accumulators. These risks are not reflected in risk estimates.

***P4 Response (SC-56)**: Please see P4's response to SC-27.*

SC-57 **4.1.1.** Delete reference to risk to livestock. See previous Table 3-5 comment.

***P4 Response (SC-57)**: Agreed. The reference to livestock risk will be deleted.*

SC-58 **4.1.2.** Tribes have an updated list of culturally significant plants for the Shoshone and Bannocks. The CS plants discussed in the FS are based on previous information, not the updated version of the CS plants. It should be noted in footnotes, that this section does not reference the most recent version of CS plants. The CS plant list was revised after the referenced sampling.

P4 Response (SC-58)*: A footnote will be added to this section and P4 requests that the USEPA provide the current list of CS plants for comparison to the CS list used during the RI/FS investigations.*

SC-59 **4.1.3.** See comment above on need to add language recognizing that achieving RAOs must consider cover profile in addition to PRGs / PCLs for soil. Develop a performance target for vegetation uptake of metals, particularly selenium. General specifications for a cover / cap will need to be developed in TM#2 in order to evaluate effectiveness and cost.

P4 Response (SC-58)*: Please see P4's response to SC-44 regarding performance targets for vegetation. General specifications for a cover/cap will be included in FS Tech Memo #2 to perform the detailed evaluation of alternatives.*

SC-60 **4.1.3.** Selected remedial alternatives for primary media address unacceptable risk posed by vegetation only if any seed mix or replanting does not include selenium-accumulating plants as mentioned in Appendix B. Include language here.

P4 Response (SC-60)*: The text from Appendix B discussing the seed mix will be summarized in Section 4.1.3.*

SC-61 **4.1.** The proposed approach to <u>not</u> monitor vegetation for COC / COEC levels and subsequently use such information for remediation evaluations does not appear to be justifiable nor protective of receptors. Although vegetation is a secondary media, it is the conduit of COC exposure for many receptors and thus should be monitored in order to assess the efficacy of primary media remediation. If COCs in vegetation fall above a given level of concern (e.g., a screening value or performance target), the efficacy of remediation of soil or sediment would come into question. Thus, please provide decision criteria for the evaluation of remediation efficacy that would include vegetation monitoring and additional assessments of remediation efficacy. If vegetation with elevated COCs is growing in primary media that are below cleanup values, risk may still exist for ecological / human receptors. Such a condition may occur if cleanup values for primary media are above both RBCLs and background levels as currently proposed.

P4 Response (SC-61)*: Please see P4's response to SC-44 regarding performance targets for vegetation. The text in Section 4.1 will be revised to discuss these performance targets.*

SC-62 **4.2.1.** Vegetation with COCs above levels of concern that is growing in primary media that has COCs below PCLs may continue to present a risk to receptors. Thus, as stated in the previous comment, please provide decision criteria and/or performance targets that could be used to trigger further assessment of the efficacy of remediation of primary media.

***P4 Response (SC-62)**: Please see P4's response to SC-44 regarding performance targets for vegetation. The text in Section 4.2.1 will be revised to discuss these performance targets.*

SC-63 **4.2.** This paragraph is somewhat confusing. It states that establishing actions for contaminated surficial materials that are associated with the waste rock is being deferred until the Remedial Design and / or RA Work Plan phase with the assertion that addressing waste rock and uplands soil will also address these media? Please clarify by further describing or referencing information on the nature and extent and volumes of these associated surficial materials.

***P4 Response (SC-63)**: The section will be revised as follows: "The waste rock is considered a source material for contaminants detected in other media at the Site. The waste rock deposition areas also contain some sediments, riparian soils, and vegetation, but remedial activities for the waste rock will also address concerns with those media as further described in Sections 4.1 and 4.4. This section then deals specifically with only upland soils and waste rock found in mine dumps throughout the Site".*

SC-64 **4.2.** <u>Seasonal Ponds</u>: Last sentence reads: "This section then deals specifically with only upland soils and waste rock found in mine dumps throughout the Site." This last sentence attempts to clarify the limitations of the upland soils and waste rock category, however, the opening paragraph of Section 4.3 then states that "seasonal ponds" are excluded from Site Surface Water and are part of the upland soils and waste rock category (Section 4.2). Clarify in Section 4.2 that the seasonal ponds within the upland soils and waste rock area are considered part of this area and the process options / technologies considered therein.

***P4 Response (SC-64)**: Section 4.2 will be revised to include a discussion that seasonal ponds will be addressed by remedial actions completed for upland soils and waste rock.*

SC-65 **4.2.** Change to "The waste rock is."

***P4 Response (SC-65)**: The text will be revised per the comment.*

SC-66 **4.2.** Consistent with general comment above, add language in this section to address radiological contaminants.

***P4 Response (SC-66)**: Please see P4's response to comments GC#3 and GC#5.*

SC-67 **4.2.1.** This is true for vegetation only if no selenium-accumulating plants are part of any reclamation efforts. Revise as needed.

***P4 Response (SC-67)**: Please see P4's response to comment SC-60.*

SC-68 **4.2.2.** The paragraph makes the following statement: "For example, the data suggest that regrading and some type of cover system for the waste rock would be the primary technologies and process options for the Site. Some technologies and process options might be applicable at sites with less volume and aerial distribution, but for large volume mine sites, such as the Ballard Site, the list of technologies that are practical is limited." It is unclear what "data" is being referred to, but if it is volume alone, then that is not a basis to eliminate technology options *at this stage* of the FS evaluation. If a technology or process option has the capability of addressing the risk and is implementable, then that process option is generally not eliminated at this phase. It would, however, be appropriate to eliminate some alternatives for large volume wastes during *later phases* of the FS evaluation. Please provide more substantiated discussion and the specific data being considered in order to determine whether to eliminate a process option at this phase.

***P4 Response (SC-68)**: The section will be revised as follows: "…For example, the Site soil and waste rock analytical data indicate elevated concentrations of Site COCs are limited to the physical boundaries of the waste rock dumps with very little to no migration to the surrounding soils. Therefore, regrading and some type of cover system for the waste rock would be the primary technologies and process options to consider for the Site."*

SC-69 **4.2.4.1.** "Site surface water" should be changed to "upland soil / waste rock"

***P4 Response (SC-69)**: The text will be revised per the comment.*

SC-70 **4.2.4.4.** Delete "thermal" as according to Table 4-2 all ex-situ treatments are eliminated.

***P4 Response (SC-70)**: Thermal will be deleted from the sentence as suggested.*

SC-71 **4.2.4.5.** Insert "to" to read "and aeration to reduce."

***P4 Response (SC-71)**: The text will be revised per the comment.*

SC-72 **4.3.1.** First sentence, reference to cleanup levels of Table 3-6: at this FS stage of the CERCLA process, these values are considered Preliminary Remediation Goals (PRGs) (see comment above on Section 3.0). Also, other locations in this paragraph and document refer to "cleanup levels" when it should be PRGs

***P4 Response (SC-72)**: Please see P4's response to comment GC#1.*

SC-73 **4.3.1.** Suggest changing "poor aquatic quality" to something like "poor quality aquatic habitat incapable of supporting fish populations."

***P4 Response (SC-73)**: The text will be revised per the comment.*

SC-74 **4.3.2.** Reference to Table 4-3 and runoff discharge – are these measurements considered the "peak" runoff discharges? Please clarify.

***P4 Response (SC-74)**: The flows reported are associated with the annual spring (high-flow) sampling. Historically, there has been an attempt to sample during the week of peak flows, but it has not always been possible to predict when this period occurs. As a result, the flow measurements represent grab sample from various parts of the yearly runoff hydrograph. The note in Table 4-3 will be revised to provide more context to runoff flows presented.*

SC-75 **4.3.2.** Seasonal Ponds: this paragraph describes the seasonal ponds and then refers the reader back to Section 4.2 where seasonal ponds are supposedly included and addressed as part of Section 4.2 —- however, Section 4.2 and Table 4-2 make no mention of "seasonal ponds" and how they will be addressed as part of the Upland soils and Waste Rock category. If seasonal ponds are going to be included in Section 4.2, please add appropriate discussion.

***P4 Response (SC-74)**: The sentence in Section 4.3.2 will be rewritten to read, "All of the other ponds are located in the mined or waste rock areas and will be addressed by remedial actions completed in those areas. As an example, regrading and capping to created positive drainage are described in Section 4.2. A major objective of these actions will be the elimination of all areas of standing water except those specifically designed to contain non-contact (clean) storm water."*

SC-76 **4.3.4.2.** Change to "Site, or infiltrates and discharges."

***P4 Response (SC-76)**: The text will be revised per the comment.*

SC-77 **4.3.4.4.** Define "POTW."

***P4 Response (SC-77)**: The text will be revised per the comment.*

SC-78 **4.4.1.** Delete the space to read "vanadium."

***P4 Response (SC-78)**: The text will be revised per the comment.*

SC-79 **4.4.1.** Eliminate the underline to read "fall within."

***P4 Response (SC-79)**: The text will be revised per the comment.*

SC-80 **4.4.1.** Insert "the" to read "near the Site."

***P4 Response (SC-80)**: The text will be revised per the comment.*

SC-81 **4.4.1.** Change "come" to "comes" for subject-verb agreement.

***P4 Response (SC-81)**: The text will be revised per the comment.*

SC-82 **4.4.2.** Last sentence states: "The area and volume assumptions listed above will be refined in subsequent iterations of this FS when the Site specific clean-up levels are approved." Note that site-specific cleanup levels are approved or finalized in the ROD. Initial indications of concurrence may be provided by the A / T during the FS phase, but typically cleanup levels are not set until the ROD.

P4 Response (SC-82)*:* *The sentence will be revised as follows: "The area and volume assumptions listed above using PCLs will be refined in the remedial design after the Site-specific clean-up levels are approved in the ROD."*

SC-83 **4.4.2.** The 30-foot average is representative not conservative as the Respondents have stated. Please change "conservative" to "representative".

P4 Response (SC-83)*:* *The text will be revised to use "representative".*

SC-84 **4.4.2.** Delete the period after document to read "document (see Section 2.3)."

P4 Response (SC-84)*:* *The text will be revised per the comment.*

SC-85 **4.4.4.4.** Change "plant" to "plants."

P4 Response (SC-85)*:* *The text will be revised per the comment.*

SC-86 **4.5.4.5.** Delete last sentence as this pertains to in-situ and this section deals with ex-situ treatments.

P4 Response (SC-86)*:* *The text will be revised per the comment.*

SC-87 **Table 4-2.** Vertical Barrier: Sheet Pile or Grout Wall: I agree that it makes sense to eliminate this process option for upland waste rock piles, but it seems like its elimination should be based on the fact that the waste rock piles are unsaturated, and as such, how would COC / COECs be expected to migrate from the soil that is also unsaturated? Restate the logic for elimination of this process option based on the lack of pathway for migration.

P4 Response (SC-87)*:* *The last sentence of the referenced portion of Table 4-2 has been revised as follows: "Based on the RI findings indicating that there is insignificant off-dump (lateral) migration of metal COCs/COECs in Site upland soils/waste rock, vertical barriers are not necessary to contain Site contaminants lateral migration. As a result, vertical barriers have been eliminated from further consideration."*

SC-88 **Table 4-2.** In line 2, change to "will result in the net reduction."

P4 Response (SC-88)*:* *The text will be revised per the comment.*

SC-89 **Table 4-2.** In line 3, change to "direct exposure to COCs / COECs."

P4 Response (SC-89)*:* *The text will be revised per the comment.*

SC-90 **Table 4-2.** Looks like this row should be under Ex-Situ Treatment. Revise accordingly.

***P4 Response (SC-90)**: The table will be reformatted as suggested.*

SC-91 **Table 4-2,** In line 3, is "fixation" the same as "solidification?" If so, then the language is fine as written. If not, change to "solidification."

***P4 Response (SC-91)**: Fixation is generally applied to chemical availability (i.e., the goal of solidification is to fixate the COCs/COECs). This chemical fixation is described in the first sentence but not defined as such. A parenthetical "(i.e., fixation)" will be added to the end first sentence so that it is defined for the reader.*

SC-92 **Table 4-2,** Removal and Disposal, Physical, Separation: For completeness, the site specific considerations describe a slurried soil separation process only, when physical waste rock separation using screens and grizzlies is more commonly used. However, based on the waste rock characteristics, it is agreed that separation will likely not be effective at this site and should be eliminated.

***P4 Response (SC-92)**: The following sentence has been added to the section of the table: "..or extract organics. Physical separation also can be implemented through the use of screens and grizzlies to break soils down into discrete sizes."*

SC-93 **Table 4-3.** "Annual" Runoff Discharge category: the notes on this table indicate that these measurements are typically made in May. This appears to be a yearly "peak" discharge measurement rather than an annual discharge (e.g., total for the year)? Please clarify.

***P4 Response (SC-93)**: In addition to revising the footnote as described in the response to comment SC-74, the word "Annual" will be deleted from the first column for both runoff and base flow discharge. These two revisions will better describe the measurements.*

SC-94 **Table 4-4.** Retention Basins / Serpentine Channels: Both of these process options for the Containment GRA claim a benefit of trapping sediment. However, how will high flow events that are likely to remobilize the trapped sediment be addressed? Through routine O&M and sediment removal?

***P4 Response (SC-94)**: The nature of the Site is that these feature will only see water during storm or runoff events (high flow events). As such, their function and design will be to collect and contain sediment from these events. Removal of accumulated sediment during routine O&M is important for preventing redistribution of the sediment should an extreme storm event occur. However, in reality, these features are only likely to be used during remedial construction, and the appropriate O&M procedures and schedules will be discussed in the design documentation. They are retained in FS Memo #1 because they will likely be a component of the reclamation, but we do not see the need to expand the discussion to O&M in the current document.*

SC-95 **Table 4-4.** Include the footnote for the "(1)" superscript.

***P4 Response (SC-95)**: The following footnotes will be added to the table:*

(1) – These technologies and process options would only be used as part of another technology, for example as a way to discharge treated water, or as part of a larger treatment system, e.g., filtration after chemical precipitation.
(2) – The treatment technologies and/or process options in the blue shaded cells have been eliminated from further evaluation in Section 5.0.

SC-96 **Table 4-4.** Delete "Ex-Situ Treatment (continued)" or move to next page and add to all other tables accordingly.

***P4 Response (SC-96)**: The formatting of the table will be corrected.*

SC-97 **Table 4-5.** Monitored Natural Recovery: It is not clear from the table's description of how the "natural recovery" process is to occur. Is it assumed that once the upstream sources of contaminated sediment / runoff are remediated that "clean" sediment will be distributed on top of the current contaminated sediment and then somehow plants will grow up through this newer clean sediment and that their rooting systems will no longer be exposed to the underlying contaminated sediment. Please provide a clear description of how the natural recovery mechanism is envisioned to work, in both text and table.

***P4 Response (SC-97)**: In accordance with the RI/FS Guidance, Section 4.0 and the associated tables present an initial screening to eliminate those technology types and process options known to have minimal effectiveness for remediation of the Site COCs/COECs or are not feasible given the Site conditions (e.g., soil types, depths of contamination, size of the Site, etc.). The information requested in the comment is included in the more detailed evaluation of the retained technologies, which is summarized in Section 5.0 (Final Screening of Remedial Technologies) and detailed in Appendix B (Details of Final Remedial Technology Screening). Specifically, Section B4.2.2 of Appendix B describes the MNR processes that are expected to occur at the Site and the resulting impacts to the affected media. Section 5.1 will be revised to 1) correct the reference from "Appendix A" to "Appendix B". In addition, cross references to Appendix B will be added as appropriate to Section 5.0.*

SC-98 **Table 4-5.** Sediment / Riparian Soils: if the risk concern is for current / future Native Americans eating aquatic plants that are growing in contaminated sediment, it seems appropriate that the "Removal" process option also include a replacement with clean sediment and replanting of the aquatic vegetation species. Was this not considered?

***P4 Response (SC-98)**: Similar to the response to SC-97, the information requested in the comment is included in the more detailed evaluation of the retained technologies, which is summarized in Section 5.0 (Final Screening of Remedial Technologies) and detailed in Appendix B (Details of Final Remedial Technology Screening). Specifically, Section B4.3.1 of Appendix B presents more details regarding the Removal and On-Site disposal option, and includes statements that the stream channels would be restored and revegetated. Section 5.1 will be revised to 1) correct the reference from "Appendix A" to*

"Appendix B". In addition, cross references to Appendix B will be added as appropriate to Section 5.0.

SC-99 **Table 4-6.** The regarding / capping source control approach for contaminated groundwater plumes: This approach may reduce future contaminants from entering the groundwater, but does nothing for the current plume of contaminated water. Perhaps regrading / capping can be a component for groundwater remediation when paired with another process option. Please describe how regrading / capping addresses the current groundwater plumes.

***P4 Response (SC-99)**: This is correct, regrading/capping is a source control and does not directly address the current distribution of COCs in groundwater. Therefore, regrading/capping needs to be coupled with MNA or more direct plume remediation. This approach is discussed in the text, but to make the table stand more on its own, the following sentence will be added – "These source control technologies will need to be coupled with an approach for managing the current COC plumes downgradient of the sources."*

SC-100 **Table 4-6.** Change "Surface Water use" to "groundwater use."

***P4 Response (SC-100)**: The text will be revised per the comment.*

SC-101 **Table 4-6.** In line 2, define "UIC."

***P4 Response (SC-101)**: UIC (Underground Injection Control) will be defined.*

SC-102 **Table 4-6.** Delete "Chemical Treatment."

***P4 Response (SC-102)**: We were not able to locate this occurrence. Did the A/T mean "Chemical Thermal"? If so, that will be addressed in correcting the table formatting issue identified in SC-103 below.*

SC-103 **Table 4-6.** Add a cell with "Thermal" in the same row as "Thermal Desorption."

***P4 Response (SC-103)**: A cell with "Thermal" will be added next to "Thermal Desorption".*

SC-104 **Tables 5-1 & 5-2.** Include a footnote similar to the footnote in Table 5-3.

***P4 Response (SC-104)**: The footnote will be added. However, no shading occurs in Table 5-1 because all technologies were retained.*

SC-105 **Table 5-1.** In line 3, insert "be" to read "may not be appropriate."

P4 Response (SC-105): *The text will be revised per the comment.*

SC-106 **Table 5-2.** Change page number to 1 of 1.

P4 Response (SC-106)*: Table 5-2 is a two page table. Page 1 of 2 and Page 2 of 2 are correct.*

SC-107 **Table 5-2.** In line 1, change "like" to "likely."

P4 Response (SC-107): *The text will be revised per the comment.*

SC-108 **Table 5-3.** Increase the cell size or revise the paragraph spacing to include all the language.

P4 Response (SC-108)*: The table will be reformatted.*

SC-109 **Table 5-4.** Delete decision rationale related to administrative challenges for discharge to surface water, reference that limits would be "overly stringent," or characterization that access across private lands is a technical issue. Permits would not be needed for discharge of effluent, although equivalent restrictions (similar to effluent limitations) would still need to be developed. Also, this would not preclude discharge to tributary streams, such as has been implemented during the treatability study.

P4 Response (SC-109)*: Under CERCLA, the on-Site remedial options must substantively comply with the local, state, and Federal requirements/regulations and any remedial options that affect off-Site areas would have to meet both substantive and administrative requirements of pertinent regulations. P4 does agree with the reviewer's assessment that permits would not be required for discharge of surface water to an on-Site drainage that discharges to the Blackfoot (i.e., a tributary to a stream feeding the Blackfoot) because Site remediation will be conducted under CERCLA. However, under CERCLA, that "on-Site discharge" still must ~~substantially~~ substantively comply with NPDES requirements, which are stringent and will require significant time and resources to ~~substantially~~ comply. Because of this, P4 will reject discharge of effluent from the groundwater treatment plant to a surface water in Table 5-4 unless the commenter is asking P4 specifically to retain this as a disposal process option in future alternatives.*

Appendix A

A-1 **Appendix A.** It is difficult to replicate the RBCLs, so as during the review of the BRA, it would be useful to for P4 to provide the actual calculation tables to review the inputs and equations. Please provide all or at least some example tables for review.

P4 Response (A-1)*: Agreed. Example RBCL spreadsheets will be provided for one or two RBCLs.*

A-2 **A2.2.** According to this section, PCLs were not calculated for seasonal ranchers because it was determined to not be a high risk receptor. However, Table 2-2 of the main text indicates that risk to seasonal ranchers is high (HI>40) through the consumption of cattle. How will this be addressed in the FS?

***P4 Response (A-2)**: PCLs were not calculated for the seasonal rancher because risk estimates for the hypothetical future resident and Native American were substantially higher than those for the seasonal rancher. Please also see P4's response to GC#2.*

A-3 **A2.1.2.** RBCLs are called out as risk based screening levels, which should be revised to be risk based cleanup levels. Also, see comments above regarding terminology and use of PRG rather than PCL at this stage of the process.

***P4 Response (A-3)**: Agreed. Text references to "risk-based screening levels (RBSLs)" will be revised to "risk-based cleanup levels (RBCLs)". Regarding use of the term "PRG" rather than "PCL", please refer to our response to GC#1.*

A-4 **A2.2.** There are several mentions of using the linear relationship between measured soil and plant tissue concentrations for the calculation of RBCLs, however it remains unclear how these were developed. Is it based on site-wide means, site-wide 95% UCLs, etc.? Clarification is necessary to complete the review of the RBCLs. This also occurs for other relationships (e.g., soil to invertebrates and vertebrates) with some describing using the Microsoft Excel Solver tool. Essentially, insufficient information has been provided in Appendix A to understand the inputs and methods used for calculating the RBCLs.\

***P4 Response (A-4)**: Agreed. Additional information will be presented in Appendix A to describe how the linear relationships between primary media and secondary media were used to calculate RBCLs.*

A-5 **A3.4.** The last sentence does not make sense and probably should be changed from "for riparian sediment, only" to "for riparian soil, only."

***P4 Response (A-5)**: Agreed. The last sentence in Section 3.4 of Appendix A will be revised to indicate that chromium and nickel were COECs in riparian soil, only.*

A-6 **Table A-1.** The uranium RBCL for elk consumption by Native Americans is nonsensical as there cannot be more than 1 million mg in a kg. Revision is necessary.

***P4 Response (A-6)**: The uranium RBCL for elk consumption was inadvertently based on the IRIS RfD of 3.0E-03 mg/kg-day for uranium; the RBCL based on the ATSDR MCL RfD of 6.0E-04 mg/kg-day is less than one million mg/kg. The uranium RBCL for elk consumption was revised based on the latter RfD. ~~The uranium RBCL for elk consumption indicates that elk consumption is an insignificant exposure pathway. The RBCL for this exposure pathway will be deleted and replaced with "n/a" and a footnote to explain that adverse health effects associated with consumption of elk are negligible.~~*

Appendix B

B-1 **B.2.3.1.** Explain why if soil caps have limited effectiveness would you expect soil caps to "may reduce if not eliminate leaching?"

P4 Response (B-1)*: The text will be revised as follows: "Soil caps having one-foot thickness are not likely effective for eliminating infiltration, but may still reduce leaching of metals from the soil/waste rock."*

B-2 **B.3.6.1.** Change to "Solid / water separation is not retained as standalone …"

P4 Response (B-2)*: The text will be revised per the comment.*

B-3 **B.3.7.1.** Reword the sentence beginning with "The biological processes …" as it reads awkwardly.

P4 Response (B-3)*: The sentence reads – "The biological processes are less active and regulated by mechanical means than compared to the ex-situ system discussed in the previous section." It will be reworded to say – "The biological processes in the wetlands system are less active and regulated compared to the more mechanical ex-situ system discussed in the previous section."*

B-4 **B.4.4.** Change to "which would require additional."

P4 Response (B-4)*: The text will be revised per the comment.*

B-5 **B.5.2.1.** Change to "applicable to all the areas."

P4 Response (B-5)*: The text will be revised per the comment.*

B-6 **B.5.5.1.** Change to "For the alluvial system, the technology would likely have …"

P4 Response (B-6)*: The text will bewas revised per the comment.*

B-7 **B.5.5.2.** Change to "May be a viable technology …"

P4 Response (B-7)*: The text will be revised per the comment.*

B-8 **B.5.6.1.** Delete "and" to read "COCs including sulfate and TDS."

P4 Response (B-8)*: The text will be revised per the comment.*

Editing Comments

***P4 Response**: The text will be revised based on the editorial comments below.*

General Editing Comments
For consistency ensure there is a following comma to read "e.g.," and "i.e.," throughout the document.
Be consistent as to whether it is "snow melt" or "snowmelt."
Be consistent on use of a hyphen for "in-situ," and "ex-situ." *There were 60 occurrences, all were hyphenated. There were no non-hyphenated occurrences. Note that the rules for hyphenating in situ and ex situ are the same as any other word. If it is an adjective, it should hyphenated like "In-situ treatment". However, "the treatment is in situ" is also correct.*
Be consistent on use of a hyphen and capitalization for "Site-specific."
Check all instances to see if "off-Site" or "off Site" is correct.
Generally "whereas," like "however," is preceded by a semi-colon when separating clauses. Revise accordingly.

Section	**Page**	**Paragraph**	**Specific Editing Comments**
1.1	1-1	1	Change to "Shoshone-Bannock Tribes (Tribes)."
2.0	2-1	1	Change to "COCs / COECs."
2.3.3	2-8	5 (last)	Change "shown and" to "shown in."
2.4	2-9	Bullet 1	Change "Drink" to "Drinking."
3.2.1	3-1	Quoted language	Unless it is how it appears in the quote, change "……" and "..." to ellipses.

Section	**Page**	**Paragraph**	**Specific Editing Comments**
Table 4-6	1 of 4	Row Containment / Vertical Barriers / Extraction Trenches	In line 3, delete the second "in the."
Table 4-6	2 of 4	Row Removal and Disposal / Disposal / Recycle / Reuse	In line 3, delete the second period.
Table 4-6	3 of 4	Row 1 (non-header rows)	Delete the line between Physical and Chemical Treatment Technologies as they are all Ex-Situ Treatments.
Table 4-6	3 of 4	Row Ex-Situ Treatment / Physical / Membrane Technologies (RO / ED / NF)	In line 3, insert a period between "effluent" and "Membrane."
Table 4-6	3 of 4	Row In-Situ Treatment / Chemical / Chemical Injection (Oxidation / Hydrolysis)	In line 5, insert "in" to read "resulting in long-term."
5.0	5-1	Bullet 2 (Implementability Evaluation	Italicize 'RI / FS Guidance" for consistency.
A2.2.2	A2-3		Change "Native America" to "Native American"
B.2.3.1	B-5	Implementability	Change to "COCs / COECs."
B.3.4.1	B-15	2 (last)	Change "pond" to "ponds."
B.3.4.1	B-16	Decision Rationale	Change "like" to "likely."
B.3.6.1	B-23	Site-Specific Considerations	Change "efficiently" to "efficiency."

Section	**Page**	**Paragraph**	**Specific Editing Comments**
B.3.6.3	B-27	Site-Specific Considerations	Change "basins" to "basin."
B.4.2.1	B-32	Bullet 2 Fencing	Change to "COCs / COECs."
B.4.2.2	B-35	1 (partial)	Insert a hyphen to read "(pre-remedial action)."
B.4.4	B-42	Bullet 2	Change "soil" to "soils."
B.5.1	B-42	Cost	Underline "Cost:" for consistency.
B.5.2.2	B-44	1	Change "need" to "needs" for subject-verb agreement.
B.5.2.2	B-45	2	Change "appropriate candidates" to "appropriate candidate."
B.5.4.1	B-48	Implementability in the Wells Formation	Change "formation" to "Formation."
B.5.6.1	B-59	Site-Specific Considerations	Change "efficiently" to "efficiency."
B.5.6.1	B-60	Site-Specific Considerations	Change "efficiently" to "efficiency."
B.5.6.1	B-61	Partial bullet	Change "each technology in this group have unique" to "each technology in this group has unique" for subject-verb agreement.
B.5.6.1	B-61	Decision Rationale	Change "blended" to "blending."
B.5.6.4	B-65	Cost	Insert a comma to read "(alluvial and / or Wells Formation)," for consistency.
B.5.7.1	B-70	Decision Rationale	Delete "via."
B.5.7.2	B-70	1	Change "principals" to "principles."

Section	Page	Paragraph	Specific Editing Comments
B.5.7.2	B-70	1	Insert “for” to read “favorable conditions for biological treatment with native bacteria.”
B.5.7.2	B-70	2	Delete the comma to read “cadmium and selenium …”
B.5.7.2	B-71	Site Specific Considerations	Change “character of the groundwater systems are” to “character of the groundwater systems is” for subject-verb agreement.
References	B-72	Smolen citation	Change period to comma to read “A.L. Lanier, 1988.” for consistency.
References	B-73	USEPA.2003 citation	Change period to comma to read “USEPA, 2003.” for consistency.

APPENDIX C-4

A/T Comments on P4 s Response to Comments (dated June 10, 2015) on *P4's Ballard Mine Feasibility Study Report, Memorandum 1 – Site Background and Screening of Technologies, Draft Rev 0, March 2015*

Transmitted to P4 on June 26, 2015

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
IDAHO OPERATIONS OFFICE
950 West Bannock, Suite 900
Boise, Idaho 83702

June 26, 2015

Molly R. Prickett
Environmental Engineer
Monsanto Company
Soda Springs Operations
1853 Highway 34
Soda Springs, Idaho 83276

Re: A/T comments on P4's Responses to Comments on the *Ballard Feasibility Study Technical Memorandum 1*

Dear Ms. Prickett,

The Agencies and Tribes (A/T) have reviewed the above referenced deliverable, submitted pursuant to the Administrative Settlement Agreement and Order on Consent/Consent Order for Performance of Remedial Investigation and Feasibility Study at the Enoch, Henry, and Ballard Mine Sites in Southeastern Idaho (or 2009 AOC). This letter transmits comments on the issues that remain to be resolved.

We will be available to discuss and clarify these comments during upcoming conference calls, and could also arrange for a separate call or meeting to discuss comments. Please contact me if you have questions. I can be reached at 208-378-5763 or electronically at tomten.dave@epa.gov.

Sincerely,

//s//

Dave Tomten
Remedial Project Manager

Attachment

cc: Mike Rowe, IDEQ - Pocatello
Sandi Fisher, US FWS - Chubbuck
Kelly Wright, Shoshone Bannock Tribes
Susan Hanson (for the tribes)
Mary Kaufman, FS – Pocatello (electronic version only)

Colleen O’Hara-Epperly, BLM (electronic version only)
Vance Drain, MWH (electronic version only)
Cary Faulk, Integrated-Geosolutions (electronic version only)
Talia Martin, Shoshone Bannock Tribes (electronic version only)
Bob Blaesing, BIA (electronic version only)
Dennis Smith, CH2MHill (electronic version only)
Gary Billman, IDL – Pocatello (electronic version only)
Jeremy Moore, US FWS – Chubbuck (electronic version only)
Charles Allbritton, EPA Records Center (electronic version only)

A/T Comments/Requests for Further Clarification of P4's Response to Comments (6-10-2015) On FS TM#1

Note: To facilitate clarity, the original A/T comment and the P4 response are presented. Additional A/T comments or request for more clarification are provided in below the P4 response.

GC#2. In draft Tech Memo #1, P4 proposed establishing soil PRGs = RBCL+BTV. This approach is a non-starter as it would set soil PRGs above upper threshold levels of the background data set, and because there is no support for this approach in policy or guidance. See also specific comments on this approach below. For soil, the methodology for establishing PRGs is a typically a step-by-step process involving first calculating concentrations of COCs in soil at an acceptable risk level (RBCLs), and then modifying the risk-based levels by considering ARARs, target risk range for various receptors, technical limitations, uncertainty, and other factors including background. There is no rigid formula for this analysis, and the process must consider a variety of factors to achieve risk management goals. In this case, because RBCLs are low relative to background, consideration of background will be a key driver in establishing soil PRGs.

At this point, based on the information provided, the A / T is not prepared to provide specific direction on a methodology for establishing soil PRGs. To advance this issue toward resolution, we believe it would be appropriate to consider some additional information or graphical presentation of existing information.

Specifically, we are requesting:

- RBCLs for all COCs for other human health exposure scenarios (in addition to residential scenario), and for all ecological receptors (in addition to the most sensitive).

- Index plots of key COCs grouped by subpopulations with potential decision statistics displayed.

- Summary table reporting USLs, UPL, and UTLs for various COCs to illustrate differences.

- A description of how soil PRGs would be applied using the amount and type of data available to make cleanup decisions, in terms of decision rules.

This information will provide additional insight that will allow for more informed and balanced risk management decisions. Proposed decision rules regarding application of PRGs will need to consider the potential for uptake by veg over an appropriate soil depth and consider how variability over a source area (including presence of hot spots) would be handled.

> ***P4 Response (GC#2)****: Based on the A/T comment, P4 is proposing that preliminary cleanup levels for purpose of evaluating alternatives in the FS are based on the higher of the lowest RBCL or background value.*

Bullet #1: The soil RBCLs in the current memorandum are based on the most conservative receptor and, and the lowest soil RBCL for a given COC/COEC is typically lower than background. As a result, PCLs for most of the COCs/ROCs are based on background values. P4 proposes to calculate soil RBCLs only for key human health receptors (i.e., seasonal rancher, recreational hunter and camper/hiker) and for key COCs/ROCs.

Bullet #2: Agreed. P4 will provide index plots for a few key soil COCs/ROCs/COECs, as described in the e-mail from Dave Tomten to Molly Prickett, dated June 3, 2015. An example is provided on the next page.

Bullet #3: Agreed. A summary table comparing statistical parameters (e.g., USLs, UTLs, and UCLs) for metals concentrations in upland background soil will be provided.

Bullet #4: Details of the anticipated confirmation sampling program (e.g., how soil sample and other data collected during the RA will be evaluated against the ROD-approved cleanup levels) typically are defined during the preparation of in the RA Work Plan (following approval of the Final Remedial Design). Therefore, we believe it is premature to define "possible" decision rules before the Site remedy is selected and the appropriate decision rules can be defined based on the Selected Remedy.

A/T Response to P4 GC2:

Note that the A / T is still not prepared to provide specific direction on soil PCLs. As we have discussed, the starting point for this risk management decision is a thorough understanding of RBCLs for all receptors. Once this information is provided (see below), we will be better positioned to consider other factors (including background, uncertainty, technical limitation, and other factors) to determine where within the acceptable risk range to establish PCLs. This more deliberate stepwise approach will help to ensure that risk managers are comfortable with soil PCLs.

The Agencies requested to have RBCLs calculated for all HH exposure scenarios/receptors that were determined to have unacceptable risks in the risk assessment to understand which species may be protected by a background-based PCL that is above the most conservative RBC. For example, if the lowest Se RBC for soil is 0.6 mg/kg for the vole and a background level is 29 mg/kg, then the PCL would be 29 mg/kg. It would be useful to know whether RBCs for elk, coyote, harriers, etc would be lower or higher than 29 mg/kg.

It is also requested that the pooled 95% UCL be added to the Index Plot.

We believe it is appropriate to provide a general description of how a PCL for soil would be applied so that the scope of remedial action may be defined. This is because there are several approaches that may be used to implement a PCL (for example, as an area average, as a not to exceed value with or without a proportion test, and other variations) which may have significant implications at some sites for the scope of action. We will provide further thoughts on this matter when we provide direction on PCLs. We agree that specific decision rules or other procedures for determining achievement of RAOs or remedy performance may be deferred to the RA Work Plan.

SC-34 **Table 2-1.** The use of footnote d is confusing and appears to be in error. Footnote d apparently indicates dissolved contaminant levels were used, however this footnote is used for sediment which is nonsensical. This footnote is also used for cattle-surface water. Unlike protection of fish, which often uses dissolved levels for comparisons with water quality criteria, cattle would be exposed to total metals concentrations. Revisions to the table are necessary.

***P4 Response (SC-34)**: Footnote d will be removed from the "Aquatic Plant - Sediment" row of Table 2-1. Although aquatic plants were evaluated for surface water COPCs, as described in the BRA, all plant tissue concentrations were based on sediment concentrations and sediment uptake factors due to uncertainty associated with surface water uptake factors.*

The use of dissolved, rather than total, metals concentration to model cattle and upper trophic level ecological surface water ingestion is consistent with the approach used in the approved Human Health and Ecological Risk Assessment Work Plan (MWH, 2011) Ballard Mine BRA (MWH, 2014), as well as the plan for long-term monitoring since 2009. The approved 2009 and 2010 Surface Water Monitoring Sampling and Analysis Plan (MWH, 2009) stated that dissolved or total metals will be used in surface water depending upon the form of the metal serving as the basis for the screening standard (i.e., the dissolved fraction for all analytes except selenium).

A/T Response to P4 SC#34 - The response that the use of dissolved, rather than total, metals concentration to model cattle surface water ingestion is consistent with the approach used in the approved HHRA and ERA Work Plan is true, however this appears to have been oversight. P4 also indicates that the approved 2009 and 2010 Surface Water Monitoring Sampling and Analysis Plan (MWH, 2009) stated that dissolved or total metals will be used in surface water depending upon the form of the metal serving as the basis for the screening standard (i.e., the dissolved fraction for all analytes except selenium), however there was no screening level for mammal surface water ingestion and cattle would not filter water prior to consumption. The screening levels P4 are referring to are for aquatic organisms. Additional discussion may be warranted to address this, although surface water ingestion is not likely as significant of an uptake pathway as soil and vegetation ingestion.

SC-36 **Drawing 2-2.** Does this drawing also include co-located sediment sample locations? Revise accordingly.

***P4 Response (SC-36)**: This drawing shows the station locations for surface water, sediment and riparian soil. It does not show the exact sample locations. For example, during the 2010 supplemental sediment and riparian soil sampling, up to five sediment locations may have been collected from select pond and stream stations. The location of these samples on Drawing 2-2 is not necessary given that Section 2.0 of FS Memo #1 is a summary of the nature and extent of* *contamination at the Ballard Site. Also, the exact location of these samples would not be distinguished given the scale of the drawing. No revisions to Drawing 2-2 are necessary.*

<u>A/T Response to SC-36 Drawing 2-2</u>. Revise the title to include the fact that sediment locations are also included in this drawing.

SC-46 **3.5.** Calculating preliminary cleanup levels for soil or sediment for a given COC / COEC by adding background concentrations (upper threshold values) and the lowest risk based screening level together would not appear to protect resident receptors from toxicological effects. This observation is based on the fact that if chemical concentrations in soil and sediment exceed a RBCL because background is added to the RBCL, the receptor for which the PCL was derived would potentially be exposed to a COC / COEC above a given toxicity value. Thus, by nature, the proposed PCLs are not conservative in that they would appear to be permitting some level of risk to sensitive receptors exposed to Site media. Despite the cited cases (in the document) in which this methodology (PCL=background + RBCL) was used, it does not appear to be adequately protective of receptors in cases where both background and RBCLs are exceeded. Also note that in the FMC example cited, that an estimate of central tendency was used as a starting point. Thus the proposed additive approach using a USL as a starting point is unacceptable. See also general comments on use of background in establishing PRGs.

P4 Response (SC-46): PCLs will be based on the higher of the most conservative receptor RBCL and background as discussed in P4's response to GC#2. However, please note that at the FMC site, the background values were an estimate of the 95% UCL on the mean concentration rather than an estimate of central tendency.

<u>A/T Response to P4 SC-46</u> – Please clarify the last sentence. The 95% UCL mean is an estimate of central tendency. The final sentence suggests otherwise.

SC-51 **3.5.** The PRG / PCL discussion incorrectly cites the FMC Plant OU to support a Risk + Background level approach. FMC utilized a Risk + Background approach, but only for radium; not for metals or other constituents. FMC also used a central tendency estimate of background, which is not comparable the proposed 95% USL (upper simultaneous limit). Because background was estimated as a central tendency, it was necessary to add a risk increment to delineate background in the field. The sum of the central tendency background estimate and a 10^{-4} cancer risk based level is significantly less than the sum of the 95% USL and 10^{-4} cancer risk based level and is likely less than the 95% USL (without the additional risk increment).

***P4 Response (SC-51)**: PCLs will be based on the higher of the most conservative receptor RBCL and background as discussed in P4's response to GC#2. However, please note that at the FMC site, the background values were an estimate of the 95% UCL on the mean concentration rather than an estimate of central tendency.*

<u>A/T Response to P4 SC-51</u> - Please clarify the last sentence. The 95% UCL on the mean is an estimate of central tendency. The last sentence suggests otherwise.

A-1 **Appendix A.** It is difficult to replicate the RBCLs, so as during the review of the BRA, it would be useful to for P4 to provide the actual calculation tables to review the inputs and equations. Please provide all or at least some example tables for review.

P4 Response (A-1)*: Agreed. Example RBCL spreadsheets will be provided for one or two RBCLs.*

A/T Response to P4 A-1 – The A/T request all spreadsheets used to calculate RBCLs.

A-2 **A2.2.** According to this section, PCLs were not calculated for seasonal ranchers because it was determined to not be a high risk receptor. However, Table 2-2 of the main text indicates that risk to seasonal ranchers is high (HI>40) through the consumption of cattle. How will this be addressed in the FS?

P4 Response (A-2)*: PCLs were not calculated for the seasonal rancher because risk estimates for the hypothetical future resident and Native American were substantially higher than those for the seasonal rancher. Please also see P4's response to GC#2.*

A/T Response to P4 A-2 - The concern is that, if the ultimate remedial action for protection of residents is institutional controls, then there would be no PCL available for less conservative receptor exposure scenario. Please provide RCBLs. See also comment above.

APPENDIX C-5

P4 s Response to Supplemental A/T Comments (dated June 26, 2015) on *P4's Ballard Mine Feasibility Study Report, Memorandum 1 – Site Background and Screening of Technologies, Draft Rev 0, March 2015*

(Second set of P4 responses. Responses to A/T comments on original P4 response to A/T comments.)

Submitted to A/T on July 15, 2015

Leah Wolf Martin

From:	Vance Drain <Vance.K.Drain@mwhglobal.com>
Sent:	Wednesday, July 15, 2015 5:07 PM
To:	Tomten, Dave; PRICKETT, MOLLY [AG/1850]; Bruce Narloch; Bruce Olenick; Cary Foulk (cfoulk@integrated-geosolutions.com); Colleen O'Hara-Epperly; COOPER, RANDALL LEE [AG/1000]; Dennis Smith (dennis.smith2@ch2m.com); Eldine Stevens; Gary Billman; Jeff Cundick; Jeff Schut; jeffrey.fromm@deq.idaho.gov; Jeremy Moore (jeremy_n_moore@fws.gov); Wallace, Joe; Kelly Wright; Leah Wolf Martin (leah@wolfmartininc.com); LEATHERMAN, CHRIS R [AG/1850]; Edmond, Lorraine; Mary Kauffman; Michael Rowe; Randy Vranes; robert.blaesing@bia.gov; Sandi Fisher; Shephard, Burt; Stifelman, Marc; Stumbo, Sherri A -FS; susanh@ida.net; tamartin@sbtribes.com; Trina Burgin; Anthony Magliocchino; Michael Gronseth
Cc:	Vance Drain
Subject:	P4's Responses to Supplemental A/T Comments on the Draft Ballard Feasibility Study Technical Memorandum #1 (Rev 0)
Attachments:	P4 RTCs supplemental AT comments on RTCs on TM1 (7-15-2015).docx; Tables 1 to 3 P4 RBCLs and Background Statistics (07-15-15).pdf; P4 Background Index Plots (07-15-15).pdf

Dear Dave et. al.,

P4 prepared and submitted the *Ballard Mine Feasibility Study Report Memorandum #1 – Site Background and Screening of Technologies - Draft Revision 0* (*Draft Ballard FS Memo #1*) on March 6, 2015. The A/Ts reviewed and submitted comments on the *Draft Ballard FS Memo #1* to P4 on May 15, 2015. P4 provided responses to the initial A/T comments (RTCs) on June 10, 2015. The A/Ts on June 26, 2015, then provided supplemental comments on P4's June 10, 2015 RTC document.

Attached to this email are P4's responses to the A/Ts' supplemental June 26th comments referenced above, index plots and risk-based cleanup levels (RBCLs) for human, ecological, and livestock receptors and background summary statistic tables as requested in your comments. The RBCL backup calculations will be submitted as soon as possible.

Please let us know if you have any questions or concerns regarding these supplemental RTCs, and we can discuss any issues that you may have during the next bi-weekly call.

Best Regards,

Vance
PM for P4
801 617 3250

P4's Responses to A/T Comments dated June 26, 2015

On P4's June 10, 2015 Responses to the A/T Comments dated May 15, 2015 on the *Feasibility Study Technical Memorandum for P4's Ballard Mine Draft Revision 0, March 2015*

Note: To facilitate clarity, the original A/T comment and the P4 response are presented. Additional A/T comments or request for more clarification are provided in below the P4 response.

GC#2. In draft Tech Memo #1, P4 proposed establishing soil PRGs = RBCL+BTV. This approach is a non-starter as it would set soil PRGs above upper threshold levels of the background data set, and because there is no support for this approach in policy or guidance. See also specific comments on this approach below. For soil, the methodology for establishing PRGs is a typically a step-by-step process involving first calculating concentrations of COCs in soil at an acceptable risk level (RBCLs), and then modifying the risk-based levels by considering ARARs, target risk range for various receptors, technical limitations, uncertainty, and other factors including background. There is no rigid formula for this analysis, and the process must consider a variety of factors to achieve risk management goals. In this case, because RBCLs are low relative to background, consideration of background will be a key driver in establishing soil PRGs.

At this point, based on the information provided, the A / T is not prepared to provide specific direction on a methodology for establishing soil PRGs. To advance this issue toward resolution, we believe it would be appropriate to consider some additional information or graphical presentation of existing information.

Specifically, we are requesting:

- RBCLs for all COCs for other human health exposure scenarios (in addition to residential scenario), and for all ecological receptors (in addition to the most sensitive).
- Index plots of key COCs grouped by subpopulations with potential decision statistics displayed.
- Summary table reporting USLs, UPL, and UTLs for various COCs to illustrate differences.
- A description of how soil PRGs would be applied using the amount and type of data available to make cleanup decisions, in terms of decision rules.

This information will provide additional insight that will allow for more informed and balanced risk management decisions. Proposed decision rules regarding application of PRGs will need to consider the potential for uptake by veg over an appropriate soil depth and consider how variability over a source area (including presence of hot spots) would be handled.

> ***P4 Response (GC#2)****: Based on the A/T comment, P4 is proposing that preliminary cleanup levels for purpose of evaluating alternatives in the FS are based on the higher of the lowest RBCL or background value.*
>
> *Bullet #1: The soil RBCLs in the current memorandum are based on the most conservative receptor and, and the lowest soil RBCL for a given COC/COEC is typically lower than background. As a result, PCLs for most of the COCs/ROCs are based on background values. P4 proposes to calculate soil RBCLs only for key human health receptors (i.e., seasonal rancher, recreational hunter and camper/hiker) and for key COCs/ROCs.*
>
> *Bullet #2: Agreed. P4 will provide index plots for a few key soil COCs/ROCs/COECs, as described in the e-mail from Dave Tomten to Molly Prickett, dated June 3, 2015. An example is provided on the next page.*
>
> *Bullet #3: Agreed. A summary table comparing statistical parameters (e.g., USLs, UTLs, and UCLs) for metals concentrations in upland background soil will be provided.*
>
> *Bullet #4: Details of the anticipated confirmation sampling program (e.g., how soil sample and other data collected during the RA will be evaluated against the ROD-approved cleanup levels) typically are defined during the preparation of in the RA Work Plan (following approval of the Final Remedial Design). Therefore, we believe it is premature to define "possible" decision rules before the Site remedy is selected and the appropriate decision rules can be defined based on the Selected Remedy.*

A/T Response to P4 GC2:

Note that the A / T is still not prepared to provide specific direction on soil PCLs. As we have discussed, the starting point for this risk management decision is a thorough understanding of RBCLs for all receptors. Once this information is provided (see below), we will be better positioned to consider other factors (including background, uncertainty, technical limitation, and other factors) to determine where within the acceptable risk range to establish PCLs. This more deliberate stepwise approach will help to ensure that risk managers are comfortable with soil PCLs.

The Agencies requested to have RBCLs calculated for all HH exposure scenarios/receptors that were determined to have unacceptable risks in the risk assessment to understand which species may be protected by a background-based PCL that is above the most conservative RBC. For example, if the lowest Se RBC for soil is 0.6 mg/kg for the vole and a background level is 29 mg/kg, then the PCL would be 29 mg/kg. It would be useful to know whether RBCs for elk, coyote, harriers, etc would be lower or higher than 29 mg/k*g*.

It is also requested that the pooled 95% UCL be added to the Index Plot.

We believe it is appropriate to provide a general description of how a PCL for soil would be applied so that the scope of remedial action may be defined. This is because there are several approaches that may be used to implement a PCL (for example, as an area average, as a not to exceed value with or without a proportion test, and other variations) which may have significant implications at some sites for the scope of action. We will provide further thoughts on this matter when we provide direction on PCLs. We agree that specific decision rules or other procedures for determining achievement of RAOs or remedy performance may be deferred to the RA Work Plan.

> ***P4's Supplemental Response (GC#2):*** *P4 has developed RBCLs for human, ecological, and livestock receptors that were evaluated in the Ballard Mine BRA. Human RBCLs are presented in Table 1 for the following receptors: hypothetical future resident, Native American, current/future seasonal rancher, current/future recreational hunter and current/future camper/hiker. Ecological RBCLs are presented in Table 2 for the following receptors: deer mouse, American robin, American goldfinch, long-tailed vole, northern harrier, coyote, elk, mink, great blue heron, mallard, and raccoon. Livestock receptor RBCLs are presented in Table 3 for cattle.*
>
> *Additional index plots for arsenic, cadmium, uranium, and radium-226 have been created and are included in <u>P4 Background Index Plots.pdf</u>. The new index plots, as well as the previous example plot for selenium, include the 95% USL, the 95-95 UTL, and the 95% UCL on the mean calculated from the pooled dataset, as well as the formation-weighted averages of the three statistics listed above.*
>
> *P4 will provide a general description of how the PCLs for soil will be applied during the remedial action in the Ballard Mine FS Memo #1 depending on the background statistic that is selected in coordination with the A/Ts. For example, statements or a flowchart will be provided that include the following:*
>
> - *Use of discrete or composite random samples over an area for comparison to the PCLs*
> - *Use of percentage for defining whether an area passes or fails (e.g., if 10% of confirmation/verification sampling results are above the PCL, further remedial action is required in an appropriately-sized area).*
> - *Regulatory guidance on the use of USLs, UTLs and UCLs on the mean concentrations during remedial decisions.*
>
> *As described in USEPA's Robust Statistical Intervals for Performance Evaluations (USEPA, 1999), the UCL, UPL and USL "…are significantly different from each other and care must be exercised to use them appropriately. For example, at a polluted site the objective may be to obtain a threshold value estimating the background level contamination prior to any activity that polluted the site. Here, the upper simultaneous limit, USL, and not the upper confidence limit, UCL, for the population mean may be used." Use of a confidence interval (e.g. UCL) for the mean or a prediction interval (e.g., UPL) for a single future observation "…is inappropriate when the objective is to*

obtain a statistical interval providing simultaneous coverage for the majority of the participants (observations).”

SC-34 Table 2-1. The use of footnote d is confusing and appears to be in error. Footnote d apparently indicates dissolved contaminant levels were used, however this footnote is used for sediment which is nonsensical. This footnote is also used for cattle-surface water. Unlike protection of fish, which often uses dissolved levels for comparisons with water quality criteria, cattle would be exposed to total metals concentrations. Revisions to the table are necessary.

P4 Response (SC-34)*: Footnote d will be removed from the "Aquatic Plant - Sediment" row of Table 2-1. Although aquatic plants were evaluated for surface water COPCs, as described in the BRA, all plant tissue concentrations were based on sediment concentrations and sediment uptake factors due to uncertainty associated with surface water uptake factors.*

The use of dissolved, rather than total, metals concentration to model cattle and upper trophic level ecological surface water ingestion is consistent with the approach used in the approved Human Health and Ecological Risk Assessment Work Plan (MWH, 2011) Ballard Mine BRA (MWH, 2014), as well as the plan for long-term monitoring since 2009. The approved 2009 and 2010 Surface Water Monitoring Sampling and Analysis Plan (MWH, 2009) stated that dissolved or total metals will be used in surface water depending upon the form of the metal serving as the basis for the screening standard (i.e., the dissolved fraction for all analytes except selenium).

A/T Response to P4 SC#34 - The response that the use of dissolved, rather than total, metals concentration to model cattle surface water ingestion is consistent with the approach used in the approved HHRA and ERA Work Plan is true, however this appears to have been oversight. P4 also indicates that the approved 2009 and 2010 Surface Water Monitoring Sampling and Analysis Plan (MWH, 2009) stated that dissolved or total metals will be used in surface water depending upon the form of the metal serving as the basis for the screening standard (i.e., the dissolved fraction for all analytes except selenium), however there was no screening level for mammal surface water ingestion and cattle would not filter water prior to consumption. The screening levels P4 are referring to are for aquatic organisms. Additional discussion may be warranted to address this, although surface water ingestion is not likely as significant of an uptake pathway as soil and vegetation ingestion.

P4’s Supplemental Response (SC-34): *Regarding the use of dissolved, rather than total, metals concentration to model surface water ingestion for cattle and upper trophic level ecological receptors. Please note that sampling investigations and risk assessments for the Area-Wide Investigation and mine-specific RIs historically have been based on dissolved surface water concentrations for metals other than selenium and total surface water concentrations for selenium as presented in the following investigations.*

- *1998 Regional Investigation (Montgomery Watson, 1999).*
- *1999 – 2000 Regional Investigation (Montgomery Watson, 2000).*

- *2004 Selenium Area Wide Investigation (IDEQ, 2005).*
- *2004 Southeast Idaho Mine-Specific Selenium Program - Comprehensive Site Investigation (MWH, 2004).*
- *2009 and 2010 Surface Water Monitoring Investigations for the P4 Mine Sites (MWH, 2009).*
- *2012 Surface Water and Groundwater Monitoring Programs for the P4 Mine Sites (MWH, 2012).*
- *2013 P4 Long-Term Surface Water and Groundwater Monitoring Plan (MWH, 2013).*
- *2014 P4 Long-Term Surface Water and Groundwater Monitoring Plan (MWH, 2014).*
- *2015 Sampling and Analysis Plan for P4 Long-Term Monitoring of Surface Water and Groundwater Ballard, Henry and Enoch Valley Mines (MWH, 2015).*

Surface water monitoring results derived from the 1998 Regional Investigation (Montgomery Watson, 1999) and the 2009 and 2010 Surface Water Monitoring Investigations for the P4 Mine Sites (MWH, 2009) were used to evaluate risks to human and ecological receptors in the Area Wide Human Health and Ecological Risk Assessment (Tetra Tech EMI, 2002) and in the Ballard Mine Remedial Investigation / Baseline Risk Assessment Report (MWH, 2014), respectively.

As the reviewer correctly points out, the surface water ingestion pathway contributed a relatively minor portion of the total exposure doses and hazard quotients (HQ) for cattle and ecological receptors in the BRA prepared for the Ballard Mine. For example, the NOAEL-based Tier II HQ estimates for beef cattle exposed to Ballard Mine upland soil, surface water, and vegetation ranged from 0.32 to 2.5, as shown in Table A5-5 of the Ballard Mine RI Report. The only chemical with a NOAEL-based Tier II hazard estimate exceeding the hazard criterion (HQ) of 1 for beef cattle is selenium (HQ = 2.5). The surface water pathway contributed 13% to the total NOAEL-based Tier II HQ estimate for beef cattle exposed to selenium at the Ballard Mine. Please note that the HQ for selenium in beef cattle was estimated using a total surface water concentration (versus a dissolved concentration) and the surface water pathway still only contributed a minor portion of the total hazard estimate. As a result, the use of dissolved versus total concentrations of COPCs and COPECs in surface water is unlikely to have a significant impact on risk estimates or RBCLs for these receptors. P4 proposes to address this issue in the Uncertainty Analysis discussion of future BRAs prepared for the Henry and Enoch Valley Mines.

SC-36 Drawing 2-2. Does this drawing also include co-located sediment sample locations? Revise accordingly.

***P4 Response (SC-36)**: This drawing shows the station locations for surface water, sediment and riparian soil. It does not show the exact sample locations. For example, during the 2010 supplemental sediment and riparian soil sampling, up to five sediment locations may have been collected from select pond and stream stations. The location of these samples on Drawing 2-2 is not necessary given that Section 2.0 of FS Memo #1 is a*

> *summary of the nature and extent of contamination at the Ballard Site. Also, the exact location of these samples would not be distinguished given the scale of the drawing. No revisions to Drawing 2-2 are necessary.*

A/T Response to SC-36 Drawing 2-2. Revise the title to include the fact that sediment locations are also included in this drawing.

> ***P4's Supplemental Response (SC-36)**: The Drawing 2-2 title will be revised to "Surface Water, Sediment, and Riparian Soil and Vegetation Sample Locations."*

SC-46 3.5. Calculating preliminary cleanup levels for soil or sediment for a given COC / COEC by adding background concentrations (upper threshold values) and the lowest risk based screening level together would not appear to protect resident receptors from toxicological effects. This observation is based on the fact that if chemical concentrations in soil and sediment exceed a RBCL because background is added to the RBCL, the receptor for which the PCL was derived would potentially be exposed to a COC / COEC above a given toxicity value. Thus, by nature, the proposed PCLs are not conservative in that they would appear to be permitting some level of risk to sensitive receptors exposed to Site media. Despite the cited cases (in the document) in which this methodology (PCL=background + RBCL) was used, it does not appear to be adequately protective of receptors in cases where both background and RBCLs are exceeded. Also note that in the FMC example cited, that an estimate of central tendency was used as a starting point. Thus the proposed additive approach using a USL as a starting point is unacceptable. See also general comments on use of background in establishing PRGs.

> **P4 Response (SC-46)**: *PCLs will be based on the higher of the most conservative receptor RBCL and background as discussed in P4's response to GC#2. However, please note that at the FMC site, the background values were an estimate of the 95% UCL on the mean concentration rather than an estimate of central tendency.*

A/T Response to P4 SC-46 – Please clarify the last sentence. The 95% UCL mean is an estimate of central tendency. The final sentence suggests otherwise.

> ***P4's Supplemental Response (SC-46)**: We misinterpreted the original comment. The RTC's included in Appendix C of the Draft Final FS Memo #1 will be revised to strikeout the last sentence.*

SC-51 3.5. The PRG / PCL discussion incorrectly cites the FMC Plant OU to support a Risk + Background level approach. FMC utilized a Risk + Background approach, but only for radium; not for metals or other constituents. FMC also used a central tendency estimate of background, which is not comparable the proposed 95% USL (upper simultaneous limit). Because background was estimated as a central tendency, it was necessary to add a risk increment to delineate background in the field. The sum of the central tendency background estimate and a 10^{-4} cancer risk based level is significantly less than the sum of the 95% USL and 10^{-4} cancer risk based level and is likely less than the 95% USL (without the additional risk increment).

> ***P4 Response (SC-51)****: PCLs will be based on the higher of the most conservative receptor RBCL and background as discussed in P4's response to GC#2. However, please note that at the FMC site, the background values were an estimate of the 95% UCL on the mean concentration rather than an estimate of central tendency.*

A/T Response to P4 SC-51 - Please clarify the last sentence. The 95% UCL on the mean is an estimate of central tendency. The last sentence suggests otherwise.

> ***P4's Supplemental Response (SC-51)****: Please refer to our response to SC-46 above.*

A-1 **Appendix A.** It is difficult to replicate the RBCLs, so as during the review of the BRA, it would be useful to for P4 to provide the actual calculation tables to review the inputs and equations. Please provide all or at least some example tables for review.

> ***P4 Response (A-1)****: Agreed. Example RBCL spreadsheets will be provided for one or two RBCLs.*

A/T Response to P4 A-1 – The A/T request all spreadsheets used to calculate RBCLs.

> ***P4's Supplemental Response (A-1)****: Agreed. The spreadsheets used to calculate RBCLs will be transmitted electronically to the A/Ts and if necessary attached to the Ballard Mine FS Memo #1.*

A-2 **A2.2.** According to this section, PCLs were not calculated for seasonal ranchers because it was determined to not be a high risk receptor. However, Table 2-2 of the main text indicates that risk to seasonal ranchers is high (HI>40) through the consumption of cattle. How will this be addressed in the FS?

> ***P4 Response (A-2)****: PCLs were not calculated for the seasonal rancher because risk estimates for the hypothetical future resident and Native American were substantially higher than those for the seasonal rancher. Please also see P4's response to GC#2.*

A/T Response to P4 A-2 - The concern is that, if the ultimate remedial action for protection of residents is institutional controls, then there would be no PCL available for less conservative receptor exposure scenario. Please provide RCBLs. See also comment above.

> ***P4's Supplemental Response (A-2)****: See P4's response to GC#2 above. RBCLs have been calculated for all human, ecological, and livestock receptors that were evaluated in the Ballard Mine BRA.*

Table 1
Soil and Sediment Human Health RBCLs and Background Statistics

	Cumulative RBCL					Background Statistic					
Primary Media COC/ROC/COEC	**Current/Future Native American [a]**	**Hypothetical Future Resident [a]**	**Current/Future Seasonal Rancher [a]**	**Current/Future Camper/Hiker [a]**	**Current/Future Recreational Hunter [a]**	**Pooled 95% USL**	**Weighted Average of 95% USL**	**Pooled 95-95 UTL**	**Weighted Average of 95-95 UTL**	**Pooled 95% UCL on the Mean**	**Weighted Average of 95% UCL on the Mean**
Upland Soil											
Antimony	0.247	0.247	28.1	2,912	3,425	3.60	1.50	3.60	1.39	1.04	0.726
Arsenic	1.31	1.26	11.2	2,074	3,104	23.3	13.2	15.6	12.9	8.20	8.69
Cadmium	8.99	14.8	81.4	8,861	10,801	44.0	22.7	41.0	21.9	13.6	10.5
Chromium	--	--	--	--	--	--	--	--	--	--	--
Copper	--	--	--	--	--	--	--	--	--	--	--
Molybdenum	31.0	2.62	61.5	59,092	78,011	29.0	10.4	29.0	10.2	7.94	6.62
Nickel	--	--	--	--	--	--	--	--	--	--	--
Radium-226	0.244	0.244	5.41	20.8	13.0	19.0	9.63	15.1	9.68	7.19	4.66
Selenium	1.23	3.61	42.4	47,017	58,280	29.0	16.2	29.0	14.9	6.67	5.23
Thallium	0.404	0.0440	0.0345	118	156	1.30	0.680	1.10	0.666	0.510	0.407
Uranium	0.439	65.8	275	7,087	9,348	42.0	19.0	36.0	18.5	10.2	8.22
Vanadium	--	--	--	--	--	--	--	--	--	--	--
Zinc	--	--	--	--	--	--	--	--	--	--	--
Riparian Soil [b]											
Arsenic	0.110	--	--	--	--	5.93	NC	5.44	NC	4.43	NC
Cadmium	7.24	--	--	--	--	5.02	NC	5.03	NC	2.81	NC
Chromium	--	--	--	--	--	--	--	--	--	--	--
Copper	--	--	--	--	--	--	--	--	--	--	--
Molybdenum	3.23	--	--	--	--	0.653	NC	0.659	NC	0.508	NC
Nickel	13.9	--	--	--	--	29.6	NC	29.7	NC	20.2	NC
Selenium	15.5	--	--	--	--	2.03	NC	2.22	NC	1.12	NC
Thallium	0.00734	--	--	--	--	0.483	NC	0.611	NC	0.333	NC
Vanadium	3.63	--	--	--	--	57.9	NC	60.6	NC	37.0	NC
Sediment [b]											
Antimony	--	--	--	--	--	--	--	--	--	--	--
Arsenic	2.33	--	--	--	--	4.55 [c]	NC	NC [c]	NC	NC [c]	NC
Cadmium	0.828	--	--	--	--	4.17	NC	4.52	NC	2.29	NC
Copper	--	--	--	--	--	--	--	--	--	--	--
Molybdenum	--	--	--	--	--	--	--	--	--	--	--
Selenium	4.70	--	--	--	--	1.48	NC	1.57	NC	1.01	NC
Thallium	--	--	--	--	--	--	--	--	--	--	--
Vanadium	--	--	--	--	--	--	--	--	--	--	--

Notes:

All concentrations are in units of milligrams per kilogram (mg/kg) with the exception of radium-226, which are in picoCuries per gram (pCi/g).

[a] The RBCL for arsenic and radium-226 are based on a target cancer risk of 1x10-4; all other RBCLs are based on a target hazard quotient of 1. The 1x10-5 and 1x10-6 cancer risks can be determined by dividing the 1x10-4 RBCL by 10 and 100, respectively.

[b] The evaluation of remedial alternatives for riparian soil and sediment are combined in Section 4.0 of this FS because it is likely that these media will have the same selected remedy as they are adjacent and contiguous. Potential future remedial activities in the sediment/riparian corridors at the Site likely will have to consider a single, unified cleanup list of cleanup levels for these media

[c] The 95% USL was selected as the proposed background level for sediment and riparian soil datasets containing five or more detections. When a dataset contained fewer than five detections, the maximum detected concentration was proposed as the background level. If there were no detected results in a dataset, the maximum detection limit for non-detects was proposed as the

Table 1 Soil and Sediment Human Health RBCLs and Background Statistics
-- not applicable; the analyte was not a COC/ROC/COEC in that medium. COC - chemical of concern COEC - chemical of ecological concern ROC - radionculide of concern NA - Not applicable NC - Not calculated ND - Not detected RBCL - risk-based cleanup level UCL - upper confidence limit USL - upper simultaneous limit UTL - upper thresold limit

Table 2
Soil and Sediment Ecological RBCLs and Background Statistics

	Cumulative RBCL											Background Statistic					
Primary Media COC/COEC	**Deer Mouse [a]**	**American Robin [a]**	**American Goldfinch [a]**	**Long-Tailed Vole [a]**	**Northern Harrier [a]**	**Coyote [a]**	**Elk [a]**	**Mink [a]**	**Great Blue Heron [a]**	**Mallard [a]**	**Raccoon [a]**	**Pooled 95% USL**	**Weighted Average of 95% USL**	**Pooled 95-95 UTL**	**Weighted Average of 95-95 UTL**	**Pooled 95% UCL on the Mean**	**Weighted Average of 95% UCL on the Mean**
Upland Soil																	
Antimony	0.703	NA	NA	3.15	NA	34.2	6,943	--	--	--	--	3.60	1.50	3.60	1.39	1.04	0.726
Arsenic	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cadmium	1.28	3.00	38.2	38.2	290	503	63,265	--	--	--	--	44.0	22.7	41.0	21.9	13.6	10.5
Chromium	86.3	74.3	90.4	247	728	2,114	440,862	--	--	--	--	420	237	410	205	108	80.1
Copper	110	74.5	88.7	195	2,052	7,198	317,302	--	--	--	--	68.3	46.7	51.9	45.3	27.0	28.4
Molybdenum	1.37	25.3	13.0	0.895	50.0	14.1	1,398	--	--	--	--	29.0	10.4	29.0	10.2	7.94	6.62
Nickel	20.7	77.5	197	112	2,489	1,489	189,385	--	--	--	--	230	112	220	109	69.8	56.6
Radium-226	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Selenium	0.864	2.70	1.30	0.605	72.1	92.8	946	--	--	--	--	29.0	16.2	29.0	14.9	6.67	5.23
Thallium	0.0400	3.78	6.07	0.0884	36.26	1.30	142	--	--	--	--	1.30	0.680	1.10	0.666	0.510	0.407
Uranium	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Vanadium	552	20.6	12.1	483	249	5,696	877,540	--	--	--	--	370	140	300	135	93.3	63.3
Zinc	1,028	729	1,426	2,562	100,200	134,182	[b]	--	--	--	--	1,200	540	1,200	536	473	412
Riparian Soil [c]																	
Arsenic	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cadmium	--	--	--	--	--	--	--	8.66	8.74	--	181	5.02	NC	5.03	NC	2.81	NC
Chromium	--	--	--	--	--	--	--	26.1	238	--	2,461	43.3	NC	45.5	NC	27.9	NC
Copper	--	--	--	--	--	--	--	9.90	220	--	4,410	24.3	NC	25.0	NC	18.5	NC
Molybdenum	--	--	--	--	--	--	--	0.495	56.3	--	53.4	0.653	NC	0.659	NC	0.508	NC
Nickel	--	--	--	--	--	--	--	11.6	206	--	960	29.6	NC	29.7	NC	20.2	NC
Selenium	--	--	--	--	--	--	--	0.110	17.0	--	105	2.03	NC	2.22	NC	1.12	NC
Thallium	--	--	--	--	--	--	--	0.0373	10.0	--	2.09	0.483	NC	0.611	NC	0.333	NC
Vanadium	--	--	--	--	--	--	--	81.5	204	--	7,916	57.9	NC	60.6	NC	37.0	NC
Sediment [c]																	
Antimony	--	--	--	--	--	--	--	0.123	NA	NA	25.8	5.00 [d]	NC	NC [d]	NC	NC [d]	NC
Arsenic	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cadmium	--	--	--	--	--	--	--	1.73	81.5	486	1,013	4.17	NC	4.52	NC	2.29	NC
Copper	--	--	--	--	--	--	--	0.831	352	3,595	11,233	25.5 [d]	NC	NC [d]	NC	NC [d]	NC
Molybdenum	--	--	--	--	--	--	--	0.541	55.9	226	88.0	<0.500 [d]	NC	NC [d]	NC	NC [d]	NC
Selenium	--	--	--	--	--	--	--	0.212	8.89	16.8	42.6	1.48	NC	1.57	NC	1.01	NC
Thallium	--	--	--	--	--	--	--	0.00770	5.53	24.1	1.68	0.378 [d]	NC	NC [d]	NC	NC [d]	NC
Vanadium	--	--	--	--	--	--	--	206	113	285	7,707	49.1	NC	52.1	NC	33.0	NC

Notes:

All concentrations are milligrams per kilogram (mg/kg).

[a] The RBCLs are based on a target hazard quotient of 1.

[b] Concentration exceeds 1,000,000 milligrams per kilogram - adverse health effects are negligble

[c] The evaluation of remedial alternatives for riparian soil and sediment are combined in Section 4.0 of this FS because it is likely that these media will have the same selected remedy as they are adjacent and contiguous. Potential future remedial activities in the sediment/riparian corridors at the Site likely will have to consider a single, unified cleanup list of cleanup levels for these media because of their proximity.

[d] The 95% USL was selected as the proposed background level for sediment and riparian soil datasets containing five or more detections. When a dataset contained fewer than five detections, the maximum detected concentration was proposed as the background level. If there were no detected results in a dataset, the maximum detection limit for non-detects was proposed as the background level.

-- not applicable; the analyte was not a COC/ROC/COEC in that medium.
COC - chemical of concern
COEC - chemical of ecological concern
NA - not available; no published toxicity information for avian species for this COEC
NC - Not calculated
RBCL - risk-based cleanup level
UCL - upper confidence limit
USL - upper simultaneous limit
UTL - upper thresold limit

Table 3 Soil Livestock RBCLs and Background Statistics							
	Cumulative RBCL	Background Statistic					
Primary Media COC/COEC/LCOC	Beef Cattle	Pooled 95% USL	Weighted Average of 95% USL	Pooled 95-95 UTL	Weighted Average of 95-95 UTL	Pooled 95% UCL on the Mean	Weighted Average of 95% UCL on the Mean
Upland Soil							
Antimony	--	--	--	--	--	--	--
Arsenic	--	--	--	--	--	--	--
Cadmium	--	--	--	--	--	--	--
Chromium	--	--	--	--	--	--	--
Copper	--	--	--	--	--	--	--
Molybdenum	--	--	--	--	--	--	--
Nickel	--	--	--	--	--	--	--
Radium-226	--	--	--	--	--	--	--
Selenium	25	29.0	16.2	29.0	14.9	6.67	5.23
Thallium	--	--	--	--	--	--	--
Uranium	--	--	--	--	--	--	--
Vanadium	--	--	--	--	--	--	--
Zinc	--	--	--	--	--	--	--

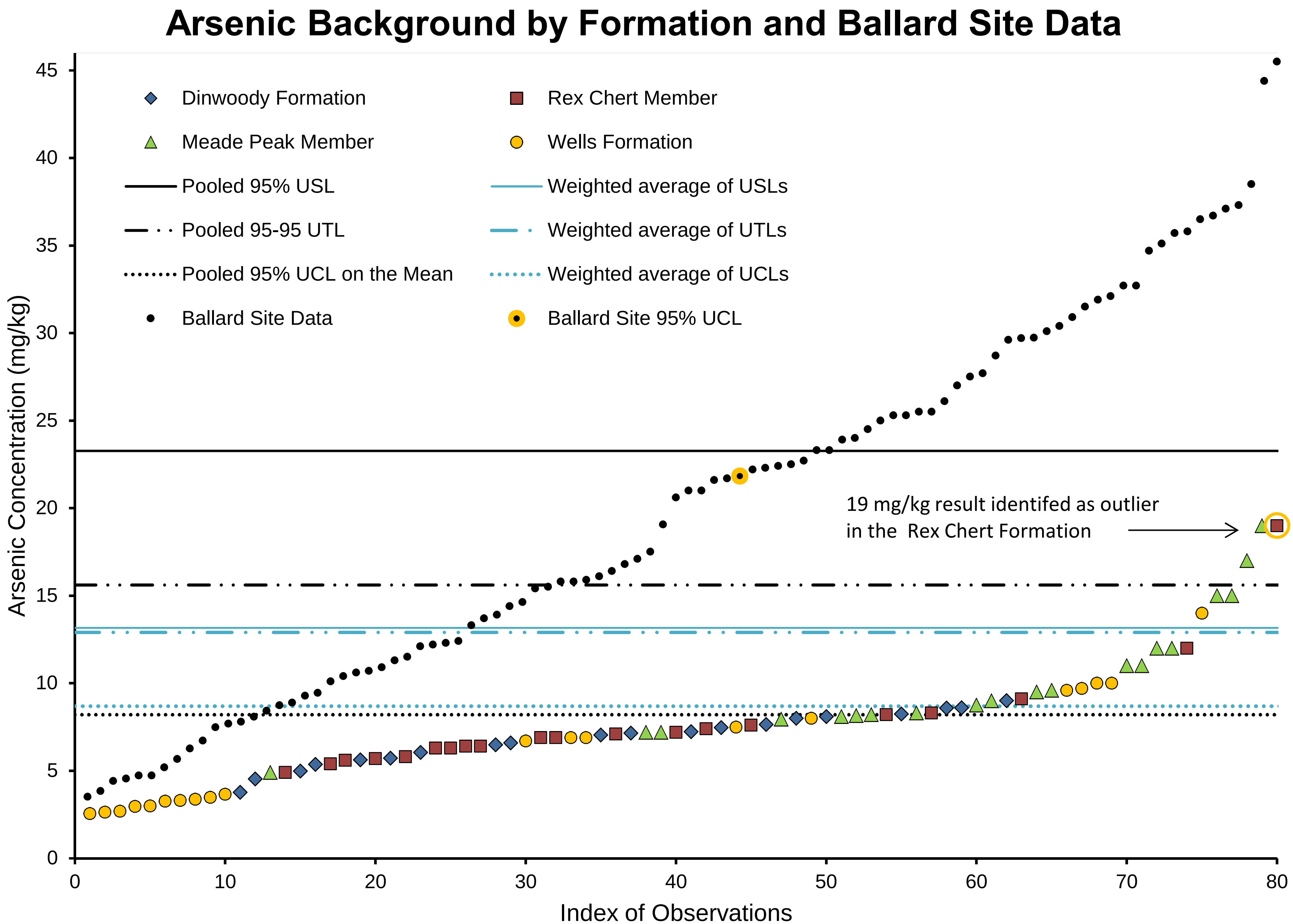
Notes:

All concentrations are milligrams per kilogram (mg/kg).

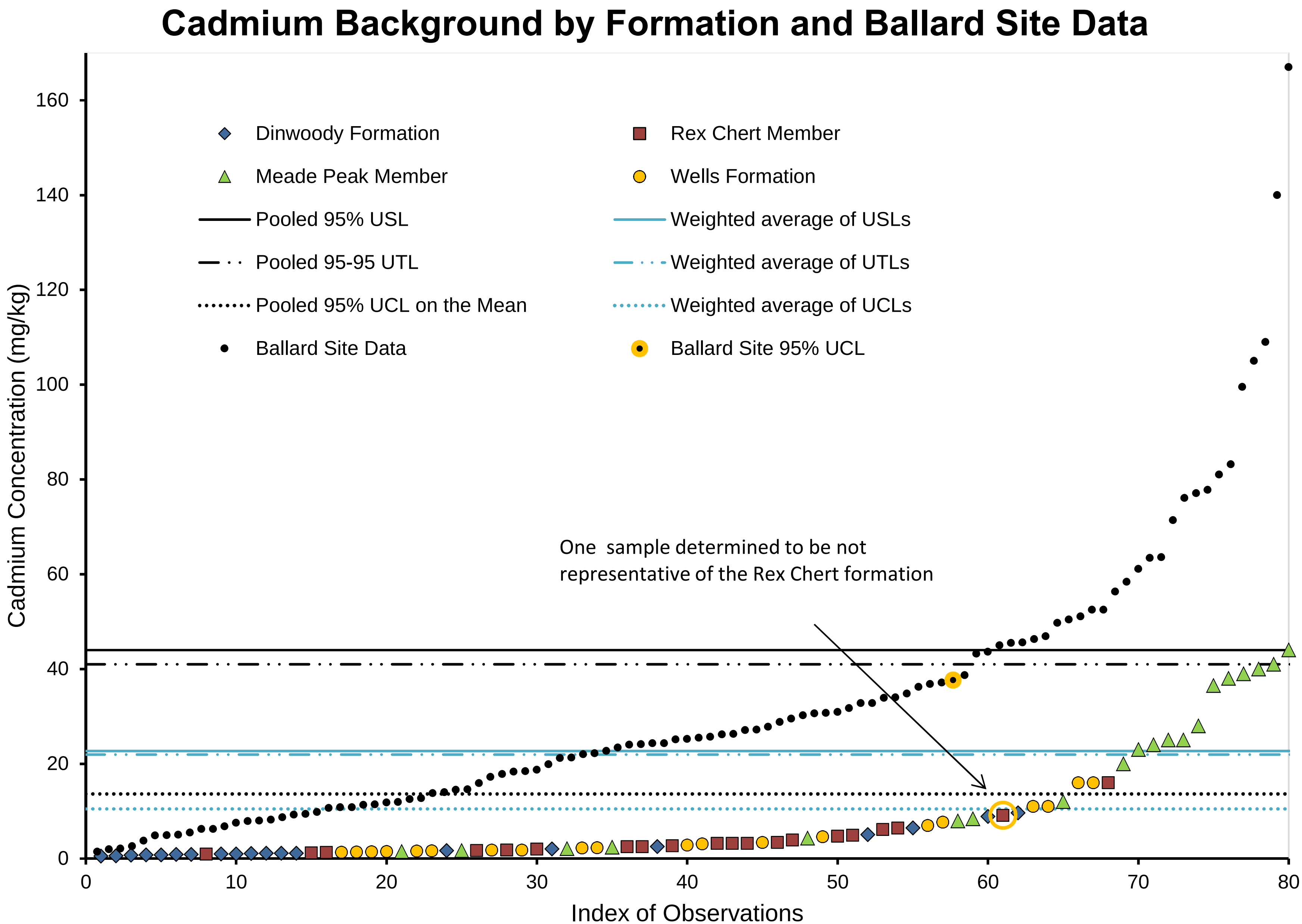
[a] The RBCLs are based on a target hazard quotient of 1.

-- not applicable; the analyte was not a COC/ROC/COEC/LCOC in that medium.

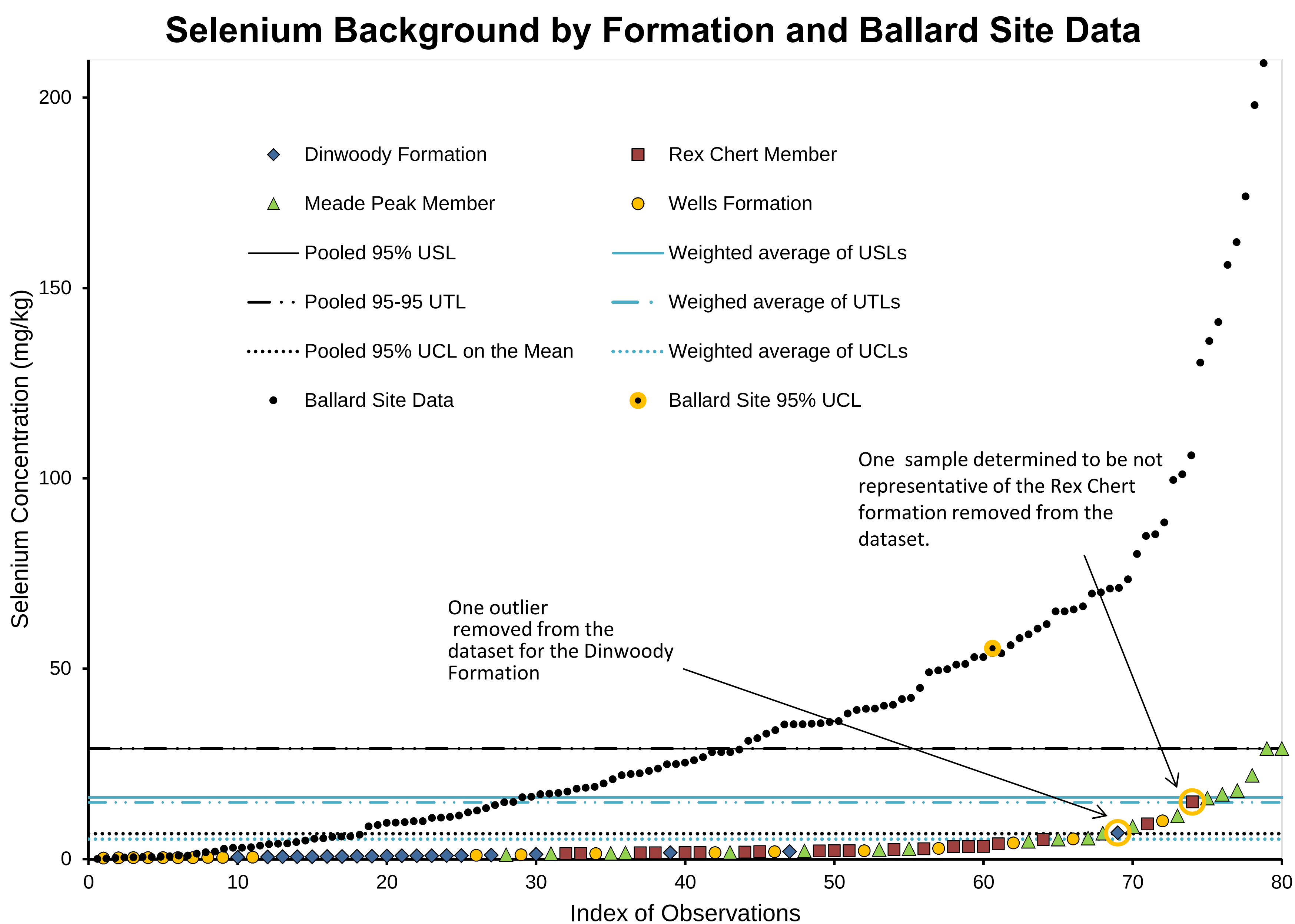
COC - chemical of concern
COEC - chemical of ecological concern
LCOC - livestock chemical of concern
RBCL - risk-based cleanup level
UCL - upper confidence limit
USL - upper simultaneous limit
UTL - upper thresold limit



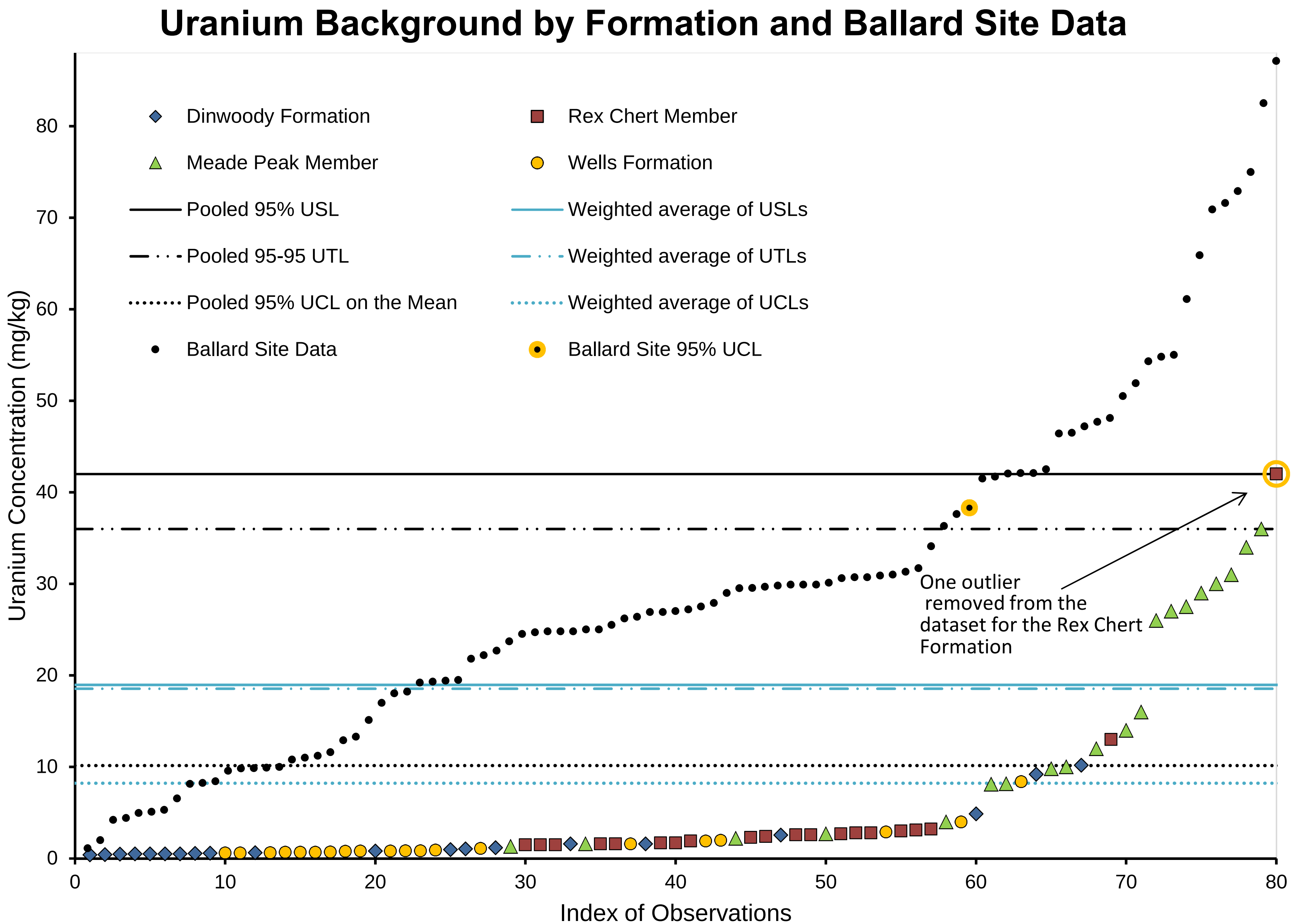
Arsenic Background by Formation and Ballard Site Data
Dinwoody Formation
Rex Chert Member
Meade Peak Member
Wells Formation
Pooled 95% USL
Weighted average of USLs
Pooled 95-95 UTL
Weighted average of UTLs
Pooled 95% UCL on the Mean
Weighted average of UCLs
Ballard Site Data
Ballard Site 95% UCL
19 mg/kg result identifed as outlier
in the Rex Chert Formation
Arsenic Concentration (mg/kg)
Index of Observations
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50
60
70
80



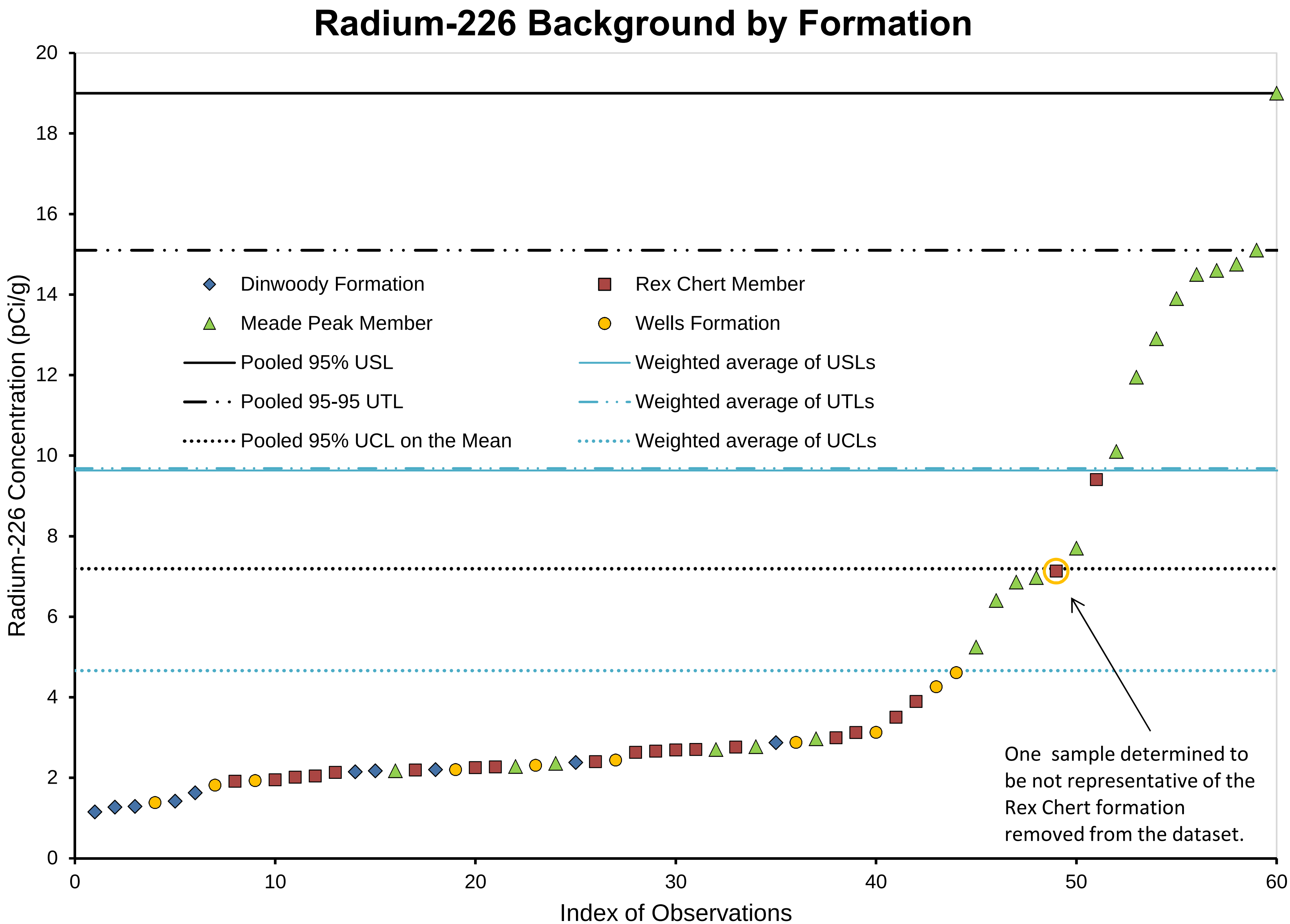
Cadmium Background by Formation and Ballard Site Data
Dinwoody Formation
Rex Chert Member
Meade Peak Member
Wells Formation
Pooled 95% USL
Weighted average of USLs
Pooled 95-95 UTL
Weighted average of UTLs
Pooled 95% UCL on the Mean
Weighted average of UCLs
Ballard Site Data
Ballard Site 95% UCL
One sample determined to be not representative of the Rex Chert formation
Cadmium Concentration (mg/kg)
Index of Observations
0
20
40
60
80
100
120
140
160
0
10
20
30
40
50
60
70
80



Selenium Background by Formation and Ballard Site Data
Selenium Concentration (mg/kg)
Index of Observations
0
50
100
150
200
0
10
20
30
40
50
60
70
80
Dinwoody Formation
Rex Chert Member
Meade Peak Member
Wells Formation
Pooled 95% USL
Weighted average of USLs
Pooled 95-95 UTL
Weighed average of UTLs
Pooled 95% UCL on the Mean
Weighted average of UCLs
Ballard Site Data
Ballard Site 95% UCL
One sample determined to be not representative of the Rex Chert formation removed from the dataset.
One outlier removed from the dataset for the Dinwoody Formation



Uranium Background by Formation and Ballard Site Data
Dinwoody Formation
Rex Chert Member
Meade Peak Member
Wells Formation
Pooled 95% USL
Weighted average of USLs
Pooled 95-95 UTL
Weighted average of UTLs
Pooled 95% UCL on the Mean
Weighted average of UCLs
Ballard Site Data
Ballard Site 95% UCL
One outlier removed from the dataset for the Rex Chert Formation
Uranium Concentration (mg/kg)
Index of Observations
0
10
20
30
40
50
60
70
80



Radium-226 Background by Formation
Radium-226 Concentration (pCi/g)
Index of Observations
0
2
4
6
8
10
12
14
16
18
20
0
10
20
30
40
50
60
Dinwoody Formation
Rex Chert Member
Meade Peak Member
Wells Formation
Pooled 95% USL
Weighted average of USLs
Pooled 95-95 UTL
Weighted average of UTLs
Pooled 95% UCL on the Mean
Weighted average of UCLs
One sample determined to be not representative of the Rex Chert formation removed from the dataset.

APPENDIX C-6

P4 Response to A/T Supplemental Comments (dated May 28, 2016) on Potential ARARs identified in *P4's Ballard Mine Feasibility Study Technical Memorandum 1, Draft Rev 0, March 2015*

Submitted to A/T on July 30, 2015

Leah Wolf Martin

From: Leah Wolf Martin <leah@wolfmartininc.com>
Sent: Thursday, July 30, 2015 6:54 PM
To: 'Tomten.Dave@epa.gov'
Cc: 'COOPER, RANDALL LEE [AG/1000]'; 'VRANES, RANDY K [AG/1850]'; 'LEATHERMAN, CHRIS R [AG/1850]'; 'PRICKETT, MOLLY [AG/1850]'; 'Vance Drain'
Subject: Ballard FS Memo #1 Revised ARAR Tables
Attachments: Draft Final Potential ARARs (7-30-15).docx; Draft Final Potential ARARs (7-30-15).pdf

Dave,

As Vance mentioned on the Monday's call, we have revised the ARAR table based on the A/Ts May 28th comments and legal input. ARARs or specific citations that are proposed for removal from the table are shown in strikeout. Rationale for removing/revising an ARAR is provided in *italics* in the Site-Specific Comments.

Please distribute these revised ARAR tables to other A/Ts as appropriate.

Please let us know if you have any questions.

Regards,

Leah

BALLARD MINE SITE: POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The following table presents a list of requirements tentatively identified by P4 Production, L.L.C. ("P4") as potential Applicable or Relevant and Appropriate Requirements ("ARARs") for the Ballard Mine Site pursuant to an Administrative Settlement Agreement and Order on Consent for Performance of Remedial Investigation and Feasibility Study at the Enoch, Henry, and Ballard Mine Sites in Southeastern Idaho dated September 28, 2009. P4 anticipates that this list of potential ARARs will be used in preparing the Feasibility Study for the Ballard Mine, including for the development of preliminary remediation goals and for use as threshold criteria against which remedial alternatives will be evaluated. P4 acknowledges that the following list of potential ARARs are not binding and that final ARARs will be developed by EPA and set forth in the Record of Decision for use as performance standards for the remedial design and remedial action.

Statutes and regulations, and their citations, included in the tables included below are provided as headings to identify general categories of potential ARARs for the convenience of the reader. Listing the statutes and regulations does not indicate acceptance of the entire statute or regulation as potential ARARs; rather only the substantive provisions of the requirements cited in these tables are potential ARARs.

Table 3-1: Federal Chemical Specific ARARs for the Ballard Mine Site

	Statutes, Regulations, Standards, or Requirements	Citations or References	General Description	Site-Specific Comments	Determination
1	Safe Drinking Water Act	42 U.S.C. §§ 300(f) *et seq.*	Protection of public water systems and underground sources of drinking water.	Potentially relevant and appropriate if groundwater beneath the Site is used to supply public water systems.	Potentially relevant and appropriate
2	National Primary Drinking Water Regulations	40 C.F.R. Part 141	Establishes health-based standards (maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs)) for public water systems.	Potentially relevant and appropriate if groundwater beneath the Site is used to supply public water systems.	Potentially relevant and appropriate
	~~Clean Water Act (CWA)~~	~~33 U.S.C. §§ 1251 *et seq.*~~	~~Governs water quality, including water discharged as part of a remedial process.~~ ~~Section 307 – Pretreatment regulations under 40 C.F.R. Part 403 provide for limits on discharge to a sanitary sewer system, protecting the municipal system from accepting wastewater that would cause it to exceed its NPDES permit discharge limits.~~ ~~Section 401 – Water Quality Certification requires that EPA receive a water quality certification from a state that a given project requiring a federal permit that may result in a discharge to navigable water will comply with the state's water quality standards.~~ ~~Section 402 – The NPDES program establishes a comprehensive framework for addressing waste water and storm water discharges under the program. Requires that point-source discharges not cause the exceedance of surface water quality standards outside the mixing zone. Specifies requirements under 40 C.F.R. § 122.26 for point-source discharge of storm water from construction sites to surface water and provides for Best Management Practices such as erosion control for removal and management of sediment to prevent run-on and runoff.~~	*We have deleted this requirement as overly broad and inclusive. Specific sections of the CWA that are either applicable or relevant and appropriate are cited elsewhere in this table.* *With regard to Section 307, it is our understanding that discharges to the sanitary sewer system are not anticipated to be included as part of the remedy.* *With regard to Section 401, implementation of the remedy will not require issuance of a federal permit (based on Section 42 U.S.C. § 9621(e)). Additionally, this requirement is administrative in nature and does not constitute an ARAR.* *With regard to Section 402, we have included this section in Table 3-3 below as an action-specific ARAR.*	

Table 3-1: Federal Chemical Specific ARARs for the Ballard Mine Site					
	Statutes, Regulations, Standards, or Requirements	**Citations or References**	**General Description**	**Site-Specific Comments**	**Determination**
3	Water Quality Standards[1]	33 U.S.C. § 1314(a) 40 C.F.R. Part 131	Section 304 of the federal Clean Water Act (33 U.S.C. § 1314) requires that individual states establish water quality standards for surface waters. The implementing regulation establishes the Ambient Water Quality Criteria, which are the minimum requirements for state water quality standards that are protective of aquatic life. Under CERCLA, water quality criteria for the protection of aquatic life are considered relevant and appropriate for actions that involve surface waters or groundwater discharges to surface waters. The federal water quality standards are developed for states to use in development of water quality criteria that incorporate designated uses for specific surface water bodies. The State of Idaho has adopted the federal water quality criteria. Where numeric state water quality standards have not been promulgated, federal numeric water quality standards are considered relevant and appropriate standards. Federal Ambient Water Quality Criteria have been established for short-term exposures (acute criteria) and for long-term exposures (chronic criteria) for protection of aquatic biota.	The State of Idaho has adopted the federal water quality criteria. Where numeric state water quality standards have not been promulgated, federal numeric water quality standards are considered applicable.	Applicable
	~~Emergency Planning and Community Right-to-Know Act (EPCRA)~~	~~42 U.S.C. §§ 11001 *et seq.*~~		*Superfund Amendments and Reauthorization Act (SARA Title III) was originally included as the standard or requirement in the table, but the U.S. Code citation was to EPCRA. We have deleted this requirement because we could not figure out why EPCRA would be ARAR for the Site.*	
	Resource Conservation and Recovery Act	~~42 U.S.C. §§ 6901 *et seq.*~~ ~~40 C.F.R. Parts 260-268~~	~~Management of solid waste. Defines threshold levels and criteria to determine if a material is hazardous waste.~~	*We have deleted this requirement as overly broad and inclusive. Specific sections of RCRA that are either applicable or relevant and appropriate are cited elsewhere in this table.*	
4		40 C.F.R. § 261.4(b)(7)	EPA exempts mining wastes from the extraction, beneficiation, and some processing of ores and minerals, in accordance with the Bevill amendment to RCRA.	Waste rock at the Site may meet this exemption.	Applicable
5		40 C.F.R. § 261.20	Generators of solid waste must determine whether the waste is hazardous. A solid waste is hazardous if it exhibits the toxicity characteristic (based on extraction procedure Method 1311).	Potentially applicable depending on the selected remedy.	Applicable
6	National Secondary Drinking Water Regulations	40 C.F.R. § Part 143	Establishes non-mandatory, secondary drinking water standards (secondary MCLs) primarily for aesthetic considerations in public water supply systems	Potentially relevant and appropriate if groundwater beneath the Site is used to supply public water systems.	TBC

[1] National Recommended Water Quality Criteria are available at http://www.epa.gov/ost/criteria/wqctable/.

Table 3-1: Federal Chemical Specific ARARs for the Ballard Mine Site					
	Statutes, Regulations, Standards, or Requirements	**Citations or References**	**General Description**	**Site-Specific Comments**	**Determination**
7	Uranium Mill Tailings Radiation Control Act (UMTRCA)— Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings	42 U.S.C. §§ 7901 *et seq.* 40 C.F.R. Part 92	Groundwater and soil concentration limits applicable to the uranium and thorium mill tailings sites identified under the UMTRCA statute.	The Ballard Mine is not a uranium mine and no processing of uranium has occurred at the Ballard Mine. Uranium at the Ballard Mine is naturally occurring and is present in the waste rock. As such uranium and its daughter products are radionuclides of concern (ROCs).	TBC
8	Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination	OSWER No. 9200.4-18, August 22, 1997	Clarifying guidance for establishing protective cleanup levels for radioactive contamination at CERCLA sites. Attachment A lists likely federal ARARs for Superfund response actions.	May be considered in remedial action due to the human health risks associated with ROCs at the Ballard Mine. Guidance documents can only be TBC.	TBC
9	DOE Licensing Requirements for Land Disposal of Radioactive Waste	10 C.F.R. § 61.41	Specifies annual dose of radioactive material that may be released to the general environment in several media.	Applicable to parties responsible for disposing of LLW received from other persons. Risk assessment utilizes ROC exposure concentrations instead of dose. May be considered in remedial action due to the human health risks associated with ROCs.	TBC
	~~Clean Air Act —~~ ~~National Emission Standards for Hazardous Air Pollutants (NESHAPs)~~	~~40 C.F.R. Part 61,~~ ~~Subparts H and I~~	~~Subparts H and I include radionuclide emission standards for Department of Energy and from other Federal facilities.~~	*We have deleted this section because the Site is not a federal facility and is not licensed by NRC.* *Subpart H—Applicable only to sites owned/operated by DOE; may be relevant and appropriate to federally-licensed NRC facilities.* *Subpart I—Applicable only to federal facilities not owned or operated by DOE and not licensed by NRC.*	

Table 3-2: State Chemical Specific ARARs for the Ballard Mine Site					
	Statutes, Regulations, Standards, or Requirements	**Citations or References**	**General Description**	**Site-Specific Comments**	**Determination**
1	Idaho Water Quality Standards	IDAPA 58.01.02	Surface water quality standards and waste water treatment requirements, including: water quality criteria for aquatic life use designations (.250), designations of surface waters found within Blackfoot Basin (.150), general surface water quality criteria (.200), antidegredation policy (.051), and mixing zone policy (.060).	Water quality standards are potentially applicable for surface waters on-Site or affected by the selected remedy.	Applicable
2	Idaho Ground Water Quality Rule	IDAPA 58.01.11.200	Protects groundwater for beneficial uses including potable water supplies, establishes use classifications, and establishes water quality criteria for ground water.	Applicable to groundwater at the Site.	Applicable
	~~Antidegredation Policy~~	~~IDAPA 58.01.02.051~~	~~Requires that existing water uses and water quality be maintained and protected.~~	*We have deleted this requirement because it is included in the "Idaho Water Quality Standards" entry included above as entry 1 in Table 3-2.*	
3	Idaho Rules for Public Drinking Water Systems	IDAPA 58.01.08	Regulates quality and safety of public drinking water.	Potentially applicable if any of the Site water is a public drinking water source; otherwise, substantive requirements would likely be relevant and appropriate.	Potentially applicable and/or relevant and appropriate
4	Rules and Standards for Hazardous Waste	IDAPA 58.01.05	Rules and standards for hazardous waste. Identifies characteristic and listed hazardous wastes and provides rules for hazardous waste permits.	Potentially relevant and appropriate if hazardous waste is identified or generated during implementation of the selected remedy.	Potentially relevant and appropriate
	~~Solid Waste Management Rules~~	~~IDAPA 58.01.06~~	~~Rules and standards for solid waste.~~	*We have deleted this requirement from Table 3-2. These rules do not appear to contain any chemical-specific requirements and the same regulation (IDAPA 58.01.06) is listed in Table 3-4 as an action -specific ARAR.*	
5	Rules for the Control of Air Pollution	IDAPA 58.01.01 (including IDAPA 58.01.01.650 and .651)	Rules providing for the control of air pollution in Idaho.	Potentially applicable depending on the selected remedy.	Potentially applicable
6	IDEQ Area Wide Risk Management Plan	IDEQ (2004a)	Recommends removal action goals and action levels for addressing releases and impacts from historical phosphate mining operations in southeast Idaho.	May be taken into consideration in developing risk-based cleanup levels.	TBC

Table 3-3: Federal Location and Action Specific ARARs for the Ballard Mine Site						
	Statutes, Regulations, Standards, or Requirements	**Citations or References**	**General Description**	**Site-Specific Comments**	**Determination**	**Location or Action Specific**
1	Mineral Leasing Act	30 U.S.C. §§ 181 *et seq.* 43 C.F.R. Parts 3500, 3580 and 3590	Regulates leasing, mining, processing and reclamation of federally-owned phosphate deposits. Prevents unnecessary or undue degradation of public lands by operations authorized by the mining laws.	Provisions regarding reclamation and mineral development are potentially applicable; other provisions may be relevant and appropriate.	Applicable	Action, Location
2	Federal Land Policy and Management Act	43 U.S.C. §§ 1701 *et seq.* 43 C.F.R. § 1600 *et seq.*	Establishes public land policy and guidelines for the administration of public lands; provides for the management, protection, development, and enhancement of public lands.	Provisions regarding mineral development are potentially applicable to the extraction of minerals; other provisions may be relevant and appropriate.	Applicable	Action, Location
3	U.S. Bureau of Land Management Record of Decision and Pocatello Resource Management Plan (April 2012)	~~40 C.F.R. § 1508.27~~ Available online at https://eplanning.blm.gov/epl-front-office/projects/nepa/32803/38812/40712/RODandSIR_508.pdf	To sustain the health, diversity, and productivity of the public lands. The plan provides objectives, land use allocations, and management direction to maintain, improve or restore resource conditions and provide for the economic needs of local communities over the long term. The plan applies to BLM-managed public lands and split estate lands where minerals are federally owned in southeast Idaho.	Should be considered due to BLM's ownership of the mineral rights. *We struck the citation to 40 C.F.R § 1508.27 because it doesn't make sense—it is a citation to the NEPA regulations' discussion regarding the term "significantly."*	TBC	Action, Location
4	Mine and Reclamation Plans		Operation plans that are approved subsequent to issuing the lease at a time after mining is proposed. Establish mine plans and reclamation requirements.	Should be considered during remedial action, especially if the remedy involves ore recovery.	TBC	Action, Location
	~~Protection of Wetlands~~	~~40 C.F.R. § 6.302~~	~~Requires federal agencies conducting certain activities to avoid (to the extent possible) the adverse impacts associated with the destruction or loss of wetlands and to not support construction in wetlands if a practical alternative exists.~~	*We do not think this section is applicable because 40 C.F.R. Part 6 identifies procedures for implementing NEPA and assessing the environmental effects of EPA actions. Subpart C "applies to actions that involve applications to EPA for permits or assistance agreements, or request other EPA approval" and identifies the requirements for environmental information documents and third-party agreements for EPA actions subject to NEPA. Section 6.302 identifies requirements applicable to the "Responsible Official" (Section 6.102 defines Responsible Official as "the EPA official responsible for compliance with NEPA for individual proposed actions"). . Please note, however, that we have included a citation to Section 404 of the CWA (see entry 11 below) to address the protection of wetland areas.*		~~Location~~
	~~Protection of Floodplains~~	~~40 C.F.R. § 6.302 and Appendix A~~	~~Requires federal agencies to evaluate the potential effects of actions they take in a floodplain to avoid the~~	*See comment regarding 40 C.F.R. § 6.302 immediately above.*		~~Location~~

Table 3-3: Federal Location and Action Specific ARARs for the Ballard Mine Site						
	Statutes, Regulations, Standards, or Requirements	**Citations or References**	**General Description**	**Site-Specific Comments**	**Determination**	**Location or Action Specific**
			~~adverse impacts associated with direct and indirect development of a floodplain.~~	*Additionally, Appendix A no longer appears in 40 C.F.R. Part 6. As a result, this requirement has been deleted as an ARAR.*		
6	Fish and Wildlife Coordination Act	16 U.S.C. § 661 *et seq.* ~~40 C.F.R. § 6.302~~	Requires that federal agencies involved in actions that will result in control or modification of any natural stream or water body must protect fish and wildlife resources that may be affected by the actions.	Potentially applicable if remedial actions affect natural streams and water bodies; the selected remedy must be designed and implemented to be protective of fish and wildlife. *We struck the reference to 40 C.F.R. § 6.302 for the same reasons explained above.*	Applicable	Location
6	Endangered Species Act	~~7 U.S.C. § 136~~ ~~16 U.S.C. § 460~~ 16 U.S.C. §§ 1531 *et seq.* ~~40 C.F.R. § 6.302~~ 50 C.F.R. Part 402	Federal Agencies are prohibited from jeopardizing threatened and endangered species or adversely modifying habitats essential to their survival. Requires consultation with the Service charged with protection of the listed species.	May be applicable if on-Site activities may jeopardize threatened or endangered species or adversely modify their habitat. *We struck the reference to 7 U.S.C. § 136 because it contains definitions for regulations concerning environmental pesticide control. We aren't sure why this section or any other sections in this chapter would be included in this table.* *We deleted the citation to 16 U.S.C. § 460 because National Parks are not located within the project boundaries.* *We deleted the reference to 40 C.F.R. § 6.302 for the same reasons explained above.*	Applicable	Location (habitat), Action (species)
7	Migratory Bird Treaty Act (MBTA)	16 U.S.C. §§ 703 *et seq.*	Prohibits persons from pursuing, hunting, taking, capturing, killing, attempting to take, capture or kill, possessing, offering for sale, selling, offering to purchase, purchasing, delivering for shipment, shipping, causing to be shipped, delivering for transportation, transporting, causing to be transported, carrying, or causing to be carried by any means whatever, receiving for shipment, transportation or carriage, or exporting migratory birds covered by the MBTA or any part, nest, or egg of any such bird.	Remedial action at the Site must be designed and implemented to avoid harm to migratory birds.	Applicable	Action
8	Bald and Golden Eagle Protection Act	16 U.S.C. §§ 668 *et seq.* 50 C.F.R. Part 22	Prohibits any person from knowingly possessing or harming a bald or golden eagle, or any part, nest, or egg thereof without obtaining a permit.	Remedial action at the Site must be designed and implemented to avoid harm to bald or golden eagles, their nests, or eggs.	Applicable	Location, Action
	~~National Pollutant Discharge Elimination~~	~~40 C.F.R. Parts 122-125~~	~~Requirements for actions involving effluent discharges to surface water.~~	*We deleted the reference as NPDES is included below as part of the CWA (see entry 10 below).*	~~Potentially relevant and appropriate~~	~~Action~~

Table 3-3: Federal Location and Action Specific ARARs for the Ballard Mine Site						
	Statutes, Regulations, Standards, or Requirements	**Citations or References**	**General Description**	**Site-Specific Comments**	**Determination**	**Location or Action Specific**
	~~System (NPDES) Regulations~~					
9	Clean Water Act	~~33 U.S.C. § 1311(b)~~ 40 C.F.R. § 125.3	Requirements for best treatment and control technology prior to discharge.	May be relevant and appropriate if water treatment is used as part of the selected remedy. *We deleted the reference to 33 U.S.C. § 1311(b) because it requires the Administrator to set requirements for best available technology for use in eliminating the discharge of pollutants. In lieu of the reference to 33 U.S.C. § 1311(b), we added a reference to 40 C.F.R. § 125.3.*	Potentially relevant and appropriate	Action
10		33 U.S.C. § 1342 40 C.F.R. Parts 122-125	The NPDES (also known as Section 402 of the CWA) program establishes a comprehensive framework for addressing waste water and storm water discharges under the program. Requires that point-source discharges not cause the exceedance of surface water quality standards outside the mixing zone. Specifies requirements under 40 C.F.R. § 122.26 for point-source discharge of storm water from construction sites to surface water and provides for Best Management Practices such as erosion control for removal and management of sediment to prevent run-on and runoff.	May be relevant and appropriate if the selected remedy involves discharges from a water treatment plant.	Potentially relevant and appropriate	Action
11		33 U.S.C. § 1344	Requirements for dredging and filling activities conducted in waters of the U.S., including wetlands (also known as Section 404 of the CWA).	May be relevant and appropriate if the selected remedy involves dredging or filling in waters of the U.S.	Potentially relevant and appropriate	Location, Action
12	Clean Air Act	42 U.S.C. §§ 7409 *et seq.* 40 C.F.R. Part 50	Requirements for maintaining air quality.	Potentially applicable depending on the selected remedy.	Potentially applicable	Action
13	National Historic Preservation Act (NHPA)	16 U.S.C. §§ 470f 36 C.F.R. Parts 60, 63 and 800 ~~40 C.F.R. § 6.301~~	A requirement for a property listed on or eligible for listing on the National Register of Historic Places. The NHPA requires federally funded projects to identify and mitigate impacts of project activities on properties listed on or eligible for listing on the National Register. This statute and implementing regulations require federal agencies to take into account the effect of this response action upon any district, site, building, structure, or object that is listed on or eligible for listing on the National Register of Historic Places (generally, 50 years old or older).	May be applicable if historic or archeological sites are found within Site boundaries or on land to be disturbed in connection with the selected remedy (*e.g.*, borrow areas). *We deleted the reference to 40 C.F.R. § 6.301 because it does not appear to be ARAR. 40 C.F.R. § 6.301 relates to preparation of an Environmental Information Document of sufficient scope and content to enable preparation of an EA or EIS and does not appear to be related to the NHPA.*	Potentially applicable	Location

Table 3-3: Federal Location and Action Specific ARARs for the Ballard Mine Site						
	Statutes, Regulations, Standards, or Requirements	**Citations or References**	**General Description**	**Site-Specific Comments**	**Determination**	**Location or Action Specific**
			If cultural resources listed on or eligible for listing on the National Register are present, it will be necessary to determine if there will be an adverse effect and, if so, how the effect may be minimized or mitigated, in consultation with the appropriate State Historic Preservation Office.			
14	Archeological and Historic Preservation Act	16 U.S.C. § 469 ~~40 C.F.R. § 6.301(c)~~	The Archaeological and Historic Preservation Act requires that for federally approved projects that may cause irreparable loss to significant scientific, prehistoric, historic, or archaeological data, the data must be preserved by the agency undertaking the project or the agency undertaking the project may request DOI to do so. This statute and implementing regulations establish requirements for the evaluation and preservation of historical and archaeological data, which may be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity or program.	May be applicable if archeological resources are identified. *We struck the citation to 40 C.F.R. § 6.301(c) because it does not appear to relate to the AHPA.*	Potentially applicable	Location
	~~Native American Graves Protection and Repatriation Act (NAGPRA)~~	~~25 U.S.C. §§ 3001 *et seq.*~~	~~Requires federal agencies and institutions that receive federal funding to return Native American cultural items to lineal descendants and culturally affiliated Indian tribes. NAGPRA also establishes procedures for the inadvertent discovery or planned excavation of Native American cultural items on federal or tribal lands.~~	*We deleted this requirement because P4 is not a federal agency or institution and because the Site boundaries do not include federal or tribal lands. However, this act will be reconsidered at the other P4 CERCLA Sites where federal land was leased.*		~~Location~~
	~~Rivers and Harbors Act~~	~~33 U.S.C. §§ 401 *et seq.*~~ ~~33 C.F.R. Parts 320-330~~	~~Requirements for minimizing adverse effects from dredge and fill activities within U.S. navigable waters and their tributaries.~~	*We deleted this requirement because we are not aware of any navigable waters located within the Site boundaries.*		~~Location, Action~~
15	RCRA— Requirements for Hazardous Waste Transport	42 U.S.C. §§ 6901 *et seq.* 40 C.F.R. Parts 261-262 ~~49 C.F.R. Parts 171-180~~	Requirements for handling and transporting hazardous waste.	Potentially relevant and appropriate depending on selected remedy. *We deleted the reference to 49 C.F.R. Parts 171-180 because these regulations are part of PHMSA, not RCRA and because PHMSA is not ARAR for the project.*	Potentially relevant and appropriate	Action
	~~Surface Mining Control and Reclamation Act (SMCRA)~~	~~30 U.S.C. §§ 1201 *et seq.*~~ ~~30 C.F.R. Parts 784 and 816~~	~~Governs activities associated with coal exploration and mining.~~	*We deleted this requirement because SMCRA is only applicable to coal mines.*		~~Action~~
16	Considering Wetlands at CERCLA Sites	OSWER 9280.03, May 1994	EPA guidance regarding the potential impacts of response actions on wetlands at Superfund sites.	May be helpful if Site remediation contains wetlands.	TBC	Action

Table 3-3: Federal Location and Action Specific ARARs for the Ballard Mine Site						
	Statutes, Regulations, Standards, or Requirements	**Citations or References**	**General Description**	**Site-Specific Comments**	**Determination**	**Location or Action Specific**
	~~Fort Bridger Treaty 1868~~	~~15 Stat 673~~	~~Established the Reservation as a "permanent home" for the signatory tribes; reserved off-reservation hunting, fishing, and gathering rights to the tribes (which rights may be exercised on "unoccupied lands of the United States").~~	*We deleted this requirement because the Site boundaries do not include federal or tribal lands. However, this treaty will be reconsidered at the other P4 CERCLA Sites where federal land was leased.*		~~Location~~
	~~Shoshone-Bannock Tribes Environmental Waste Management Program. Soil Cleanup Standards for Contaminated Properties, December 2, 2010.~~	~~Tribal Resolution ENVR-2011-0022 January 6, 2011~~	~~Soil cleanup standards for contaminated properties~~	*We deleted this requirement because the Site boundaries do not include tribal lands. Please note that the intent of this Tribal program has already substantively been captured by other applicable state and federal laws.*		~~Location~~

Table 3-4: State Location and Action Specific ARARs for the Ballard Mine Site						
	Statutes, Regulations, Standards, or Requirements	**Citations or References**	**General Description**	**Site-Specific Comments**	**Determination**	**Location or Action Specific**
1	Protection of Birds	Idaho Code Ann. § 36-1102	Prohibits the "take" or intentional disturbance or destruction of eggs or nests of any "game, song, rodent killing, insectivorous or other innocent bird." The prohibition does not apply to English Sparrows or starlings.	Potentially applicable during remedial action.	Potentially applicable	Action
2	Non-point Source Discharges	IDAPA 58.01.02.350	Regulates non-point source discharges, designates approved BMPs and provides additional protection for outstanding resource waters.	May be applicable if the selected remedy results in non-point source discharges.	Potentially applicable	Action
3	Point Source Discharges	IDAPA 58.01.02.400-.401	Provides limits and restrictions including possible limits on temperature and flow rates for point source discharges.	May be applicable if the selected remedy results in point source discharges.	Potentially applicable	Action
4	Storage of Hazardous and Deleterious Materials	IDAPA 58.01.02.800	Prohibits the storage, disposal or accumulation of hazardous and deleterious materials "adjacent to or in the immediate vicinity of state waters" without adequate measures and controls to insure the materials will not enter state waters.	May be relevant and appropriate if the remedial action results in the storage of hazardous and deleterious materials near state waters.	Potentially relevant and appropriate	Action
5	Well Construction Standard Rules	IDAPA 37.03.09	Regulates well construction and abandonment.	May be applicable if the selected remedy includes additional wells.	Potentially applicable	Action
6	Best Management Practices and Reclamation for Surface Mining Operations	IDAPA 20.03.02.140	Provides BMP and reclamation standards for surface mining operations, including sand and gravel mining.	May be applicable depending on the selected remedy. BMPs may also be relevant and appropriate to remediation activities (i.e. grading, re-contouring, and revegetation).	Potentially applicable and/or relevant and appropriate	Action
7	Idaho Water Quality Standards and Wastewater Treatment Requirements	IDAPA 58.01.02	Requirements for actions involving effluent discharges to surface water.	May be applicable if water treatment is part of the selected remedy.	Potentially applicable	Action
	~~Surface Mining~~	~~Idaho Code §§ 47-1501 to -1519~~ ~~IDAPA 20.03.02.140~~	~~Establishes standards and authorizes rules for reclaiming lands affected by surface exploration and mining, including recontouring, erosion control, and revegetation.~~	*We deleted this requirement because it is duplicative of entry 7 above. Citations to Idaho Code §§ 47-1501 to -1519 allow for the establishment of standards so they are not ARAR; rather, the substantive BMPs in the regulations (cited in entry 7 above) are the potentially ARAR standards.*		~~Action~~
8	Solid Waste Management Rules	IDAPA 58.01.06	Provides substantive requirements for operation and closure of solid waste management facilities.	Only material uniquely associated with phosphate mining is being addressed in the remediation so these requirements are not applicable because the Site is not a solid waste management facility. See IDAPA 58.01.06.001.03(b)(iv). Some requirements may be relevant and appropriate with regard to	Potentially relevant and appropriate	Action

Table 3-4: State Location and Action Specific ARARs for the Ballard Mine Site						
	Statutes, Regulations, Standards, or Requirements	**Citations or References**	**General Description**	**Site-Specific Comments**	**Determination**	**Location or Action Specific**
				regulated solid waste generated during the remedial action.		
9	Hazardous Waste and Hazardous Waste Management Act of 1983	IDAPA 58.01.05 1993 Session Law, Ch. 291, Sections 1-8	Adopts federal RCRA regulations concerning the identification of hazardous waste and standards applicable to generators and transporters of hazardous waste as well as standards for owners and operators of hazardous waste treatment, storage and disposal facilities.	Potentially applicable for management of investigation derived wastes and remediation wastes.	Potentially applicable	Action
	~~Site Specific Surface Water Quality Criteria~~	~~IDAPA 58.01.02.275 to 280~~	~~Establishes surface water quality standards for water discharged from dams, reservoirs and hydroelectric facilities and for other named waters.~~	*We deleted this requirement because it does not relate to conditions at the Site. Section 275 sets criteria for promulgating site specific standards—this would be more appropriately included as a chemical-specific ARAR because it sets forth criteria for establishing an alternative water quality standard for specific COCs at the Site. All of IDAPA 58.01.02 is included in the chemical-specific ARARs Table 3-2 above.* *Section 276 is the damn/reservoir requirement and only sets dissolved oxygen standards for below a dam/reservoir, but it is no dam or reservoir exists within the Site boundaries.* *Sections 277 and 279 are reserved, Section 278 relates to the Lower Boise River Subbasin, and Section 280 applies to Rock Creek, Cedar Draw, Deep Creek and the Big Wood River Canal System.*		~~Location~~
10	Fences in General (LEAs)	Idaho Code §§ 35-101 to -112	Establishes construction requirements, such as height and distance between posts, for all types of fences. Defines who is responsible for construction and maintenance of enclosure and partition fences.	May be applicable if fencing is required to protect components of the selected remedy (e.g., a cover system).	Potentially applicable	Action
11	Idaho Rules for Control of Fugitive Dust	IDAPA 58.01.01.650-651	Provides practices for controlling fugitive dust emissions, including use of water or chemicals, application of dust suppressant, and covering trucks.	May be applicable during remedial action if construction practices generate fugitive dust.	Potentially applicable	Action
12	Idaho Toxic Air Pollutants	IDAPA 58.01.01.585-586	Requirements for maintaining air quality (none currently nor will they be likely associated with any remedial action).	Potentially applicable depending on the selected remedy.	Potentially applicable	Action

Table 3-4: State Location and Action Specific ARARs for the Ballard Mine Site

	Statutes, Regulations, Standards, or Requirements	Citations or References	General Description	Site-Specific Comments	Determination	Location or Action Specific
13	Preservation of Historical Sites	Idaho Code §§ 67-4111 to -4131 and 67-4601 to -4619	Requirements for protection of public lands and preservation of historical or archaeological sites in consideration of waste disposal.	Requirements may be applicable if historical or archeological sites are present and/or may be disturbed during the remedial action.	Potentially applicable	Location
14	Stream Channel Alteration Rules	~~Idaho Code §§ 42-3801 to -3812~~ IDAPA 37.03.07.055	Provides substantive construction standards for working in stream channels.	Potentially applicable depending on selected remedy; however, procedural requirements are not ARAR. *We deleted the reference to Idaho Code §§ 42-3801 to -3812 because it contains procedural requirements and allows for substantive requirements to be promulgated.*	Potentially applicable	Action
15	Idaho Classification and Protection of Wildlife Rule	IDAPA 13.01.06.300	Classifies fish and wildlife species; identifies threatened or endangered species; and specifies wildlife species that are protected from taking and possessing.	To be considered during ecological risk assessment.	TBC	Location
16	~~Idaho Land Remediation Rules~~ Idaho Uniform Environmental Covenants Act	~~IDAPA 58.01.18.027~~ Idaho Code §§55-3001 to -3015	~~Rules applicable to eligible persons who wish to enter into a voluntary remediation agreement with the state.~~ Allows recordation of an environmental covenant, which is a written agreement where the parties bind themselves, and their successors in interest to the land, to comply with activity and use limitations.	*We recommend deleting IDAPA 58.01.18.027 because it relates to the institutional controls portion of the Idaho VRP program. Since we are not entering into the VRP, and because this is an administrative program, we recommend deleting.*	Applicable	Action
	~~Guidelines for the Salvage of Topsoil and Shale Used to Reclaim and Provide Seed Bed for Phosphate Mine Reclamation.~~	~~USFS (2003)~~		*We deleted this requirement because a copy of these guidelines is not available.*		~~Action~~
17	IDEQ Area Wide Risk Management Plan	IDEQ (2004a)	Recommends removal action goals and action levels for addressing releases and impacts from historical phosphate mining operations in southeast Idaho.	May be taken into consideration in developing risk-based cleanup levels.	TBC	Action
	~~Guidance document for regional removal action goals and objectives, and action levels~~	~~IDEQ (December 2003)~~	~~Guidance document for risk-based decision-making using human health and transport models.~~	*We deleted this ARAR because it refers to a draft of the Idaho Risk Evaluation manual included below (entry 19 below), so is repetitious.*		~~Action~~
18	Variances from water quality standards	IDAPA 58.01.02.260	Establishes procedures and requirements for obtaining a water quality variance.	Potentially applicable if Site-specific variances are proposed for a particular location or source.	Potentially applicable	Action
19	Idaho Risk Evaluation Manual	IDEQ (2004b) Available online at https://www.deq.idaho.gov/media/967298-risk_evaluation_manual_2004.pdf	Provides guidelines and criteria to apply in risk-based decision making.	Framework for decision making should be considered in developing human and environmental risk-based cleanup levels	TBC	Action

APPENDIX C-7

A/T Preliminary Direction Regarding Consideration of Background in establishing Soil PRGs/PCLs

Transmitted to P4 on August 25, 2015

Leah Wolf Martin

From:	Tomten, Dave <Tomten.Dave@epa.gov>
Sent:	Tuesday, August 25, 2015 9:24 AM
To:	Bruce Narloch; Bruce Olenick; Cary Foulk (cfoulk@integrated-geosolutions.com); Celeste Christensen; Colleen O'Hara-Epperly; COOPER, RANDALL LEE [AG/1000]; Tomten, Dave; Dennis Smith (dennis.smith2@ch2m.com); Eldine Stevens; Emily Yeager; Gary Billman; Jeff Cundick; Jeff Schut; jeffrey.fromm@deq.idaho.gov; Jeremy Moore (jeremy_n_moore@fws.gov); Wallace, Joe; Kelly Wright; Leah Wolf Martin (leah@wolfmartininc.com); LEATHERMAN, CHRIS R [AG/1850]; Edmond, Lorraine; Mary Kauffman; Michael Rowe; PRICKETT, MOLLY [AG/1850]; Randy Vranes; robert.blaesing@bia.gov; Sandi Fisher; Shephard, Burt; Stifelman, Marc; Stumbo, Sherri A -FS; susanh@ida.net; tamartin@sbtribes.com; Trina Burgin; Vance Drain
Subject:	A/T preliminary direction regarding consideration of background in establishing soil PRGs/PCLs
Attachments:	Tables 1 to 3 P4 RBCLs and Background Statistics (07-15-15).pdf; P4 Background Index Plots (07-15-15).pdf; SERAS-106-DTMR1-081315_61.pdf

Molly, all –
This follows up on previous discussions related to consideration of background in establishing soil PRGs, and provides preliminary direction for resolving this matter and moving forward. We are characterizing this direction as "preliminary" as there are many factors to consider in establishing soil PRGs/PCLs, and the A/T are interested in your input to ensure thorough consideration of technical limitations, uncertainty and other pertinent information.

As part of the effort to resolve this issue, we have consulted with two senior-level statisticians as well as project risk assessors and scientists. Based on these discussions, there appears to be broad agreement on several important points.

- The preferred approach is to base the PRG/PCL on a BTV, rather than approaches using the UCL of the mean, or hypothesis testing.
- Given the distribution of data, the UTL is strongly preferred over the USL (or other BTV statistics). The distribution of data, including the presence of many statistical outliers, was unknown at the time the work plan was developed (when use of a USL was originally proposed). This makes a difference for some COCs but little difference for Se.
- A BTV-based PRG/PCL would be applied by comparing individual site observations to the PRG (a point-by-point method), and thus control maximum values in an area to be remediated. Also, cleanup decisions could be made for portions of dumps rather than treating an entire dump as a decision unit.

An issue that remains is estimating the BTV, given that the data set has limitations, does not follow a defined distribution, contains multiple (sub)populations, and shows significant variability. We have identified two options that we believe are acceptable. Both are consistent with EPA guidance, and clearly distinguish waste materials from natural soil.

- Option 1 (suggested by Dr. Singh) would be to compute the BTV for just the dominant portion of the data set (by excluding about 10% of the higher values) and use that as the PRG. This approach would yield a Se PRG of approx. 8 ppm. Decision errors could be mitigated by combining this PRG with a "proportion test." In the proportion test, the team would specify some percentage of onsite observations that would be allowed to exceed the PRG (based on the truncated data set). When combining a proportion test with a BTV-based PRG, decisions would be made for an entire decision unit.
- Option 2 (suggested by Dr. Hilshire) would be to compute the BTV for the entire data set (including statistical outliers that have been investigated and are thought to represent natural background values) and use that as the PRG. This approach would yield a Se PRG of about 29 ppm.

Both of these options have a number of pros and cons. Based on discussions to this point, the A/T prefers the **second option**, for a number of reasons including: 1) it would be simpler to implement, and provide flexibility in addressing portions of dumps as needed; 2) we are reluctant to exclude observations that have been investigated and thought to reflect natural variability in the background population; and 3) other considerations.

Keep in mind a couple of other points. At Ballard, concentration of contaminants in surface materials are generally much higher than either PRG option. Cleanup decisions in many cases will be driven by the need to address releases to groundwater and surface water, and construction of covers to protect water resources will address exposure to contaminated surface materials. Also, soil PRGs would be implemented as point-by-point comparisons and would control the highest values – thus, average site concentrations (and risk) following remediation would be lower than a risk associated with the PRG concentration.

We would be interested in hearing your thoughts on this matter during our next call. We should be able to provide final direction for moving forward after that call. As always, call if you have Q's.
Dave

Attachments
1. Background Analyte Index Plots, by Formation, for the Ballard Mine (from P4, 7/15/15)
2. RBCLs and Background Statistics (from P4, 7/15/15)
3. Singh technical memo

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LOCKHEED MARTIN

DATE: August 13, 2015

TO: Felicia Barnett, Director SCMTSC, EPA

FROM: Anita Singh, Ph.D., SERAS Statistician DJH for A.S.

THROUGH: Richard Leuser, SERAS Deputy Program Manager

SUBJECT: REVISED - METHODS TO ESTABLISH PRELIMINARY REMEDIATION GOALS (PRGS) AND DECISON RULES FOR APPLICATION OF PRGS FOR SURFACE MATERIALS SOIL ON WASTE ROCK DUMPS AT THE P4 PHOSPHATE MINES (P4 MINES), SERAS-106, WO 60

Background Information

United States Environmental Protection Agency (US EPA) Region 10 (R10) scientists are in the process of developing Remediation Investigation and Feasibility Studies (RI/FSs) for a number of large phosphate mines including: Ballard, Enoch Valley and Henry mines located in South-East Idaho. These mines were operated by P4 LLC Inc.; therefore collectively these mines are referred to as P4 Mines (Site). The Site consists of several geological formations including: Meade Peak, Rex Chert, Wells and Dinwoody. For convenience, many abbreviations for the three mines, background areas, formations, and mine/formation combinations have been used in the graphical displays presented in this Lockheed Martin Technical Memorandum (TM) and are listed in Table 1. The P4 Mines listed above consist of large open pits and waste rock dumps (wst-rck-dmps) which contain contaminants of potential concern (COPCs) and radionuclides of potential concern (ROPCs). The various waste-rock-dumps of the three mines have been labeled (separately) as wst1-rck-dmp, wst2-rck-dmp, and so on, in the graphical displays and tables used in this TM. The COPCs/ROPCs pose unacceptable risks to people and animals that use these areas.

Based upon the background data collected during 2009 and 2014, it was determined that the existing risk based cleanup levels (RBCLs) for most COPCs are low relative to background concentrations. For example, from the Excel sheet (labeled as Appendix D), "PRG-Table-Ballard-FS-with-Updated-BTVs.xlsx," provided by R10 personnel, it is noted that for selenium (Se) in soil the:

- Current background concentration is 1.8 milligrams per kilogram (mg/kg);
- Human health RBCL (for the most conservative receptor) is 1.23 mg/kg;
- Ecological RBCL for the most conservative receptor is 0.6 mg/kg; and
- Proposed cleanup level is 2.40 mg/kg.

From this Excel sheet, it is also noted that for Se, a background concentration of 29 mg/kg (95% upper simultaneous limit [USL95]) and weighted background concentration of 16.2 mg/kg were computed based upon the combined data set collected during 2009 and 2014. Therefore, R10 personnel need to appropriately determine and establish background levels/preliminary remedial goals (PRGs) and decision rules for the application of PRGs for the surface materials/soil on the waste rock dumps. These PRGs and decision rules will be used to determine whether waste dumps or portions of waste dumps will need to be

covered with clean material to protect human health and the environment. More information about the Site can be found at:
http://yosemite.epa.gov/r10/cleanup.nsf/7d19cd587dff1eee8825685f007d56b7/0ccd0ad659e095ef8825774300578be0!opendocument

Areas from which to collect background samples were required to meet the following criteria: 1) undisturbed by mining or waste rock disposal; 2) representative of the geology where waste rock dumps have been placed; and 3) comparable in aerial extent to the waste rock dumps that were characterized at the Site during the 2009 Supplemental Soil and Vegetation Characterization program. Two areas: Blackfoot Bridge and Caldwell Canyon were selected as background areas. During 2014, background soil samples (n=72) were collected from the four geological formations (Meade Peak, Rex Chert, and Wells and Dinwoody) of the selected background areas, representing the entire geologic sequence that ultimately was disturbed by mining operations. The sampled background areas consist primarily of native vegetation and undisturbed soil; however the occurrences of COPC/ROPC detections are widespread in background areas across the above mentioned geologic formations. During 2009, 39 background samples were collected from undisturbed mine/formation combination areas: Ballard-Wells, Henry-Dinwoody, and Enoch-Dinwoody. The background data collected in 2009 and 2014 will be used to establish PRGs which will be used in the decision making process (e.g., cover or not cover waste dumps with clean soil).

On May 14, a conference call was held with R10 personnel to discuss the objectives and scope of the work assignment (WA). Some issues associated with establishing PRGs were discussed. Specifically, due to high natural variability and substantial differences in concentrations of the COPCs of the geological formations, it is not easy to establish background data sets and compute PRGs for all onsite areas of the P4 Mines. It is noted that the Meade Peak formation exhibits significantly higher background concentrations than the other three geological formations. As discussed during the conference call, due to difficulties associated with the implementation of PRGs, it is not practical/desirable to establish separate PRGs for the four formations present at the site. R10 is asking for guidance: in establishing PRGs/BTVs for the P4 Mines, and in developing defensible and practical decision rules to perform background versus site comparisons. Selenium (Se) was identified as one of the key COPCs.

1.0 Objectives

In mid May 2015, Mr. Stifelman and Mr. Tomten of USEPA R10 requested the assistance of the Site Characterization and Monitoring Technical Support Center (SCMTSC) to provide guidance on: how to establish PRGs for the various COPCs identified at the Site; and how to develop and implement decision rules based upon those PRGs. Two documents (MHW 2013 and MWH 2015) summarizing statistical evaluations on background data and an Excel file called, "Appendix D" consisting of background data for the COPCs/ROPCs collected from the four formations of the background areas were provided by Mr. Stifelman.

As described in the WA, the objectives of the background evaluations summarized in this TM are:

1. Identify range of options for consideration of background data in establishing PRGs;
2. Outline decision rules for application of PRGs for the surface materials/soil on the waste rock dumps;
3. Outline pros and cons of each of the suggested option; and
4. Review and comment on the use of background threshold value (BTV): USL versus upper tolerance limit (UTL) versus upper prediction limit (UPL) selection.

During a subsequent conference call with Mr. Tomten, he mentioned that it might not be feasible and prudent to remediate mine areas of concern (AOCs) which have already been re-claimed based upon a single exceedance of the BTV/PRG by an onsite observation. He wanted guidance on applying PRGs to make cleanup decisions at such AOCs. Taking this scenario into consideration, for onsite areas which have been re-claimed, instead of performing point-by-point onsite comparison with a BTV, the use of a proportion test allowing a certain percentage of exceedances of BTV by AOC observations has been suggested. The project team selects an allowable proportion, p_0 exceedances of a BTV before triggering a further remediation/investigation decision (e.g., covering or not covering waste dumps or portions of waste dumps with clean material). Mr. Tomten also requested some guidance on generating and using index plots to compare onsite data with background data and established BTVs/PRGs. Following the conference call, an onsite Se data set collected from the three P4 mines was provided by Mr. Tomten. The onsite data set has been used in Section 3.3 illustrating the generation of color-coded (symbol-coded) index plots (Singh and Nocerino, 1995) comparing onsite data with background data and suggested PRG(s).

The approaches to address the objectives listed have been discussed in Sections 2 and 3. As desired by Mr. Tomten, background versus onsite comparisons have been illustrated by using index plots which are described in Section 3.0. Section 4.0 summarizes evaluations comparing BTV estimates computed using the 2009 background data and the combined 2009 and 2014 background data. ProUCL 5.0 (EPA 2014) has been used to generate quantile-quantile (Q-Q) plots, box plots, and compute all statistics including upper limits used to estimate BTVs/PRGs. Software Scout 2008 v1.00.00 (EPA 2009) has been used to generate index plots.

2.0 Options for Establishing PRGs to Perform Background versus Site Comparisons and Associated Pros and Cons

Establishing a PRG based upon a background data set depends upon its application and intended future use. Typically, BTV estimates such as a 95% upper percentile, a 95% UPL (UPL95), a 95% UTL with 95% coverage (UTL95-95), a USL95; or a 95% upper confidence limit of the mean (UCL95) are used to establish PRGs. Based upon the project needs, the project team selects the most appropriate upper limit to establish a PRG. The detailed description of these upper limits with interpretation is provided in Chapter 3 of the ProUCL 5.0 Technical Guide (EPA 2014).

2.1 Using a BTV and Proportion Test

2.1.1 Using a BTV to Establish a PRG

A BTV is estimated based upon an established (as determined by the project team) background data set. BTVs are used when point-by-point onsite observations (e.g., Se concentrations) are compared with a BTV estimate. Typically, an exceedance of a BTV/PRG by an onsite observation potentially triggers the further investigation decision at the location associated with that observation.

<u>This approach may be used when decisions are made individually for each sampled location in an AOC.</u>

Depending upon the statistic used, this approach may lead to a high number of false positives in an AOC. The most commonly used value to estimate a BTV is a UTL95-95. The use of a UPL95 to estimate a BTV results in a high number of false positives especially when more than a few (e.g., >3-4) individual AOC comparisons are made with a UPL95. On the other hand, the use of a USL95 may yield a high number of false negatives for an AOC unless the background data set represents a single statistical population and does not consist of outliers. More details about the upper limits used to estimate BTVs and associated pros and cons of those limits are provided in Chapter 3 of the ProUCL 5.0 Technical Guide.

<u>Caution about the use of a USL</u>: A USL represents a limit on the maximum value in a data set and is intended for use when the data set represents a single population free of outliers (representing observations from a different population). Unlike a UTL, by definition, a USL does not assume that a certain percentage of the data set (in this case the background data set) may not belong to background population (implicitly assuming that all observations in the data set come from the same population). As described in ProUCL guidance, a USL may not be used for a BTV when a background data set includes statistical outliers and/or a mixture population, as is the case here. A ProUCL generated output sheet displays a similar message about the use of a USL to determine a BTV estimate.

Statistical and graphical evaluations performed on the P4 Mines ackground data indicate that background data collected from the four geologic formations within the two background areas represent multiple statistical populations. In this scenario, a USL can be significantly high and may represent an unrealistically high value for a background BTV.

<u>If all the stakeholders involved determine that the elevated Meade Peak data represents valid background concentrations, then USLs are not recommended for establishing project PRGs.</u>

2.1.2 Using a BTV and Proportion Test to Determine the Status of an AOC

To control the number of false positives associated with the point-by-point comparison approach used for an AOC, one can perform a one-sample proportion test with the BTV/PRG as an action level. Applying expert site knowledge and regional geochemistry when using the proportion test, the project team selects an allowable proportion, p_0 (e.g., 5%, 10%), of exceedances of the action level (PRG) by observations from an AOC before triggering an investigation/remediation decision at that AOC. Once a PRG has been established based upon a background data set, the following hypothesis is tested.

Null Hypothesis (H_0): Proportion, p, of exceedances of PRG by onsite observations in an AOC$<=p_0$, versus the
Alternative Hypothesis (H_1): Proportion, p, of exceedances of PRG by onsite observations in that AOC $>p_0$

The proportion, p, of an AOC (population proportion) is estimated by the sample proportion of exceedances of a BTV given as follows:

Sample proportion is equal to the number of observed exceedances of a PRG in an AOC divided by the total number of comparisons made with the PRG for that AOC.

<u>This approach may be used when decisions are made for the entire AOC.</u>

If for an AOC, the null hypothesis is not rejected, the project team may walk away from that AOC without performing further investigations. The details of performing a proportion test are provided in the ProUCL 5.0 Technical Guide, where a PRG is used as an action level. ProUCL 5.0 software can be used to perform a proportion test.

2.2 Using a UCL95 to Establish a PRG

A confidence interval (CI) of mean or a UCL95 of mean can also be used to perform background versus site comparisons. Unlike a BTV, a UCL95 represents an estimate of the mean of the background population. A 95% CI (or a 90% CI to yield a 95% UCL) of mean is computed based upon a background data set; and if the average of an onsite AOC does not belong to the computed 90% CI, it is inferred that the means of the two populations are not comparable with confidence coefficient of 0.90. In the present context, a UCL95 can be used to establish a PRG; an exceedance of a background UCL95, PRG, by the average value of an AOC potentially triggers the further investigation decision for that AOC as a whole.

A UCL95 of background mean may be used to establish a PRG when the cleanup decisions are made for an AOC (and not for an individual Site location). The AOC average should be computed based upon a data set representative of that AOC. The use of averages of AOCs does not account for spatial information and the decisions are made for the entire AOC. This option may lead to incorrect decisions, for example cleaning some of the clean locations and not cleaning some of the dirty locations within an AOC. Therefore, this approach may not be used for large AOCs. ProUCL 5.0 software can compute parametric and nonparametric UCL95s for data sets with and without nondetect (ND) observations.

2.3 Hypothesis Tests to Perform Site vs. Background Comparisons

Equivalently, one can use two-sample hypotheses testing approaches to perform site versus background comparisons, provided enough background and onsite data (e.g., ten or more from each population, preferably computed using data quality objectives) are available. The commonly used two-sample hypotheses tests are: t-test, Wilcoxon-Mann-Whitney (WMW) test, and Gehan test. The details of these testing approaches are given in the ProUCL 5.0 Technical Guide. These approaches compare means or medians of two populations (background versus Site).

An advantage of using the UCL95/PRG approach over the hypothesis testing approaches to perform site versus background comparisons is that there are several parametric and nonparametric methods available to compute a UCL95 for data sets with and without NDs. Not many parametric (e.g., for gamma distributed data sets) and nonparametric hypotheses tests are readily available for data sets with and without ND observations.

3.0 Evaluation of Background Data for Selenium (Se)

The Se background data set collected during 2009 and 2014, provided by Mr. Tomten, has been used to illustrate the suggested options to establish PRGs and perform background versus Site comparisons for the various COPCs. All units are reported in mg/kg. Emphasis is given on the use of formal index plots to compare onsite data with background data and PRGs displayed on those index plots; similar approaches can be used for the other COPCs identified at the Site.

As mentioned earlier, the project team needs to determine which approach will be applicable to address their project needs. Based upon the available information and discussions with Mr. Tomten, it appears that the use of BTVs will be most appropriate to establish PRGs for the P4 Mines Site. Therefore, PRGs for Se have been established using upper limits used to estimate BTVs.

A background dataset of size 111 for Se collected during 2009 (from undisturbed areas of Ballard, Enoch, and Henry) and during 2014 (Blackfoot Bridge and Caldwell Canyon background areas) representing the four geological formations present at the P4 Mines was provided by Mr. Tomten. In this data set, 39 observations were collected during 2009, and 72 observations were collected in 2014 from the two background areas: Blackfoot Bridge and Caldwell Canyon. He mentioned that concentrations of the COPCs present in the four formations of the background areas are highly variable and the Meade-Peak formation exhibits higher concentrations in comparison with the other three formations. Considering the presence of high variability among the four formations, one may want to establish separate PRGs for the each formation. Mr. Tomten suggested that since PRGs need to be established for many COPCs, and concentrations from many waste dumps and mine pits will be compared with those PRGs, from an implementation point of view, it would not be desirable and practical to develop separate BTVs/PRGs for the four formations. Evaluations summarized in this TM have been performed keeping these issues and concerns in mind.

The entire background data set of size 111 represents 11 background area and formation combinations (categories): Meade-Peak/Canyon; Dinwoody/Canyon; Rex-Chert/Canyon; Meade-Peak/Bridge; Wells/Canyon; Dinwoody/Bridge; Rex-Chert/Bridge; Wells/Bridge; Dinwoody/Henry; Wells/Ballard and Dinwoody/Enoch Valley. For convenience, in tables and graphical displays used in this TM, the abbreviations summarized in Table 1 have been used for the 11 formation/area background categories.

Table 1 – List of Abbreviations used in Graphs and Statistical Analyses

Formation or Area	Abbreviation
Meade-Peak/Caldwell Canyon	Md-Pk-Cnyn
Dinwoody/Caldwell Canyon	Dnwoody-Cnyn
Rex-Chert/Caldwell Canyon	Rex-Chrt-Cnyn
Mead-Peak/Blackfoot Bridge	Md-Pk-Brdg
Rex-Chert/Blackfoot Bride	Rex-Chrt-Brdg
Dinwoody/Blackfoot Bridge	Dnwoody-Brdg
Wells/Caldwell Canyon	Wells-Cnyn
Wells/Blackfoot Bridge	Wells-Brdg
Wells/Ballard	Wells-Ballard
Dinwoody/Henry	Dnwoody-Hnry
Dinwoody/Enoch Valley	Dnwoody-Ench

Figure 1 has box plots and Figure 2 has Q-Q plots comparing background Se concentrations of the four geological formations (irrespective of the background area sampled). Summary statistics for background data from the four formations are presented in Table 2. From Figures 1 and 2, and Table 2, it is noted that the combined Meade-Peak formation data from the two background areas indeed exhibits higher Se concentrations in comparison with the other three formations.

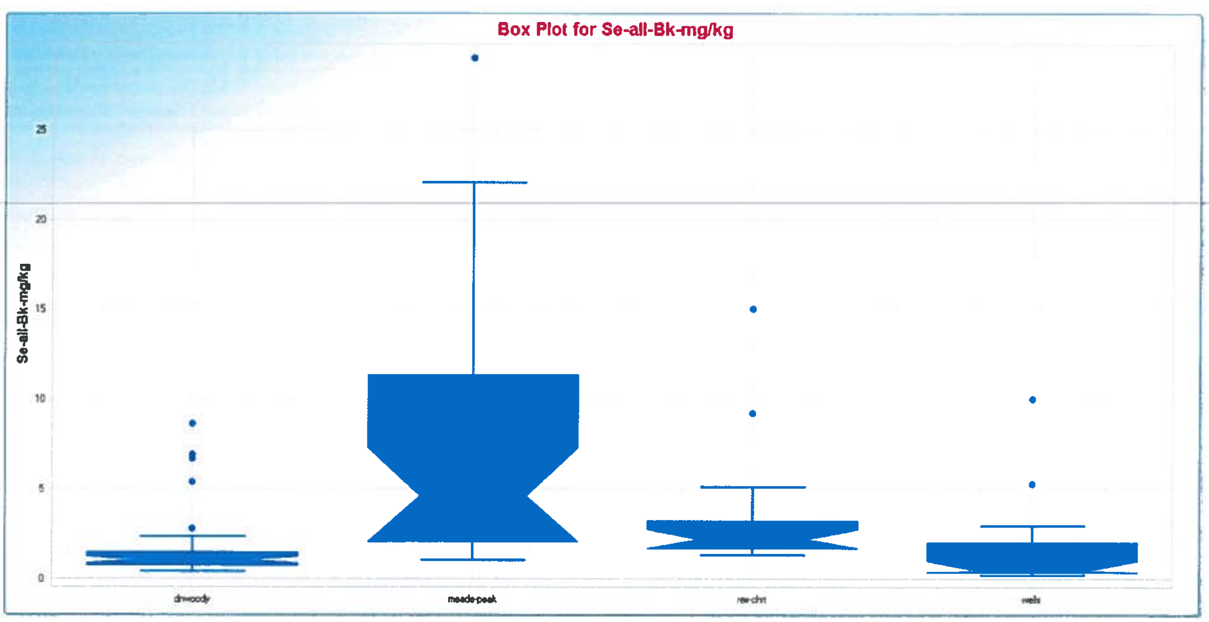

Figure 1. Box Plots Comparing Se in Soils of Four Geological Formations (in Background Areas)

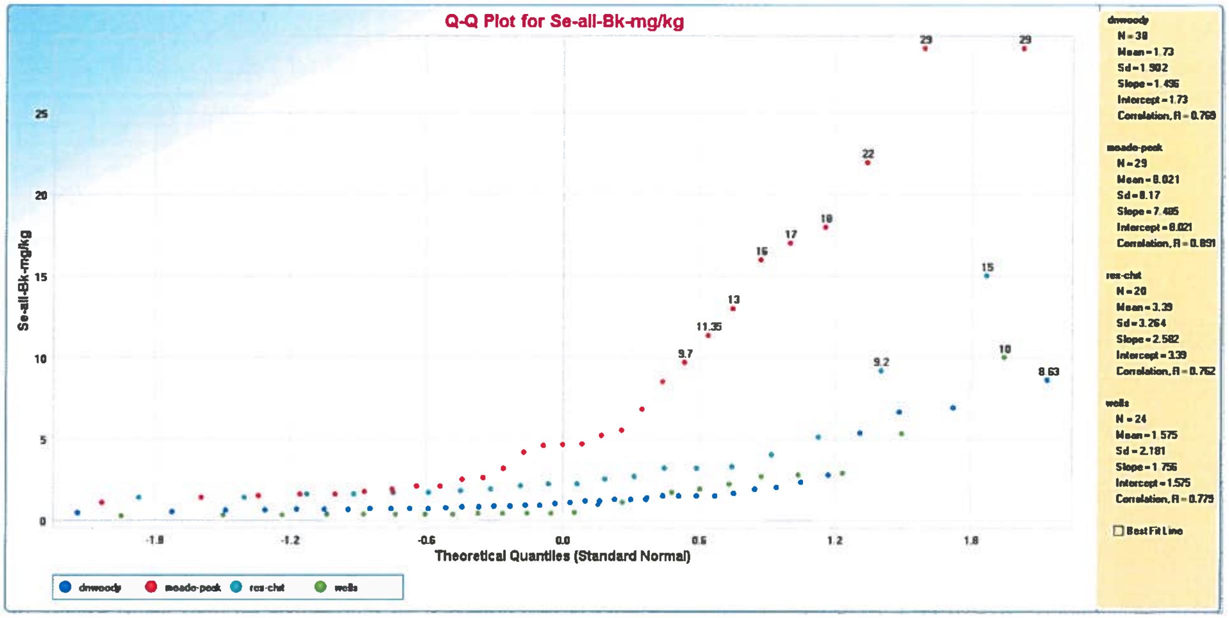

Figure 2. Q-Q Plots Comparing Se in Soils of Four Geological Formations (in Background Areas)

Table 2. Summary Statistics for Se in Four Formations of Background Areas

General Statistics for Uncensored Data Sets

Variable	NumObs	# Missing	Minimum	Maximum	Mean	SD	SEM	MAD/0.675	Skewness	Kurtosis	CV
Se-all-Bk-mg/kg (dnwoody)	38	0	0.477	8.63	1.73	1.902	0.309	0.576	2.55	5.874	1.1
Se-all-Bk-mg/kg (meade-peak)	29	0	1.1	29	8.021	8.17	1.517	4.522	1.451	1.265	1.019
Se-all-Bk-mg/kg (rex-chrt)	20	0	1.4	15	3.39	3.264	0.73	0.89	2.884	8.804	0.963
Se-all-Bk-mg/kg (wells)	24	0	0.25	10	1.575	2.181	0.445	0.276	2.89	9.701	1.385

Percentiles for Uncensored Data Sets

Variable	NumObs	# Missing	10%ile	20%ile	25%ile(Q1)	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile	99%ile
Se-all-Bk-mg/kg (dnwoody)	38	0	0.642	0.704	0.737	1.06	1.5	1.804	3.574	6.686	7.986
Se-all-Bk-mg/kg (meade-peak)	29	0	1.58	1.84	2.1	4.65	11.35	14.2	18.8	26.2	29
Se-all-Bk-mg/kg (rex-chrt)	20	0	1.58	1.68	1.7	2.2	3.225	3.44	5.51	9.49	13.9
Se-all-Bk-mg/kg (wells)	24	0	0.319	0.364	0.374	0.452	1.975	2.4	2.87	4.94	8.919

For a closer look, box plots comparing Se concentrations of the 11 categories present in the background data set of size 111 are shown in Figure 3, and Table 3 has summary statistics for those 11 categories. From Figure 3 and Table 3, it is noted that the Meade-Peak formation of the Blackfoot Bridge background area exhibits the highest Se concentrations. The six highest concentrations of the background data set of size 111 come from the Meade-Peak-Blackfoot Bridge category (Figure 5) which consists of only 13 observations. From Table 3, it is noted that for this category, all statistics including mean, median and other percentiles (e.g., 80%, 90%, 95%, etc.) are substantially higher than those of the other 10 background categories. From Figure 3 and Table 3, it is also observed that Se concentrations of the Meade-Peak formation from the Caldwell Canyon background area are not higher than the rest of the nine background categories, as can be seen in the box plots shown in Figure 4 comparing Se concentrations of the 10 background categories (excluding Meade-Peak/Blackfoot Bridge). Figures 3 and 4 suggest that Se of Meade-Peak formation are higher only in the Blackfoot Bridge area, and Se concentration in the Md-Pk-Cnyn background category are in the range comparable to the other nine background categories.

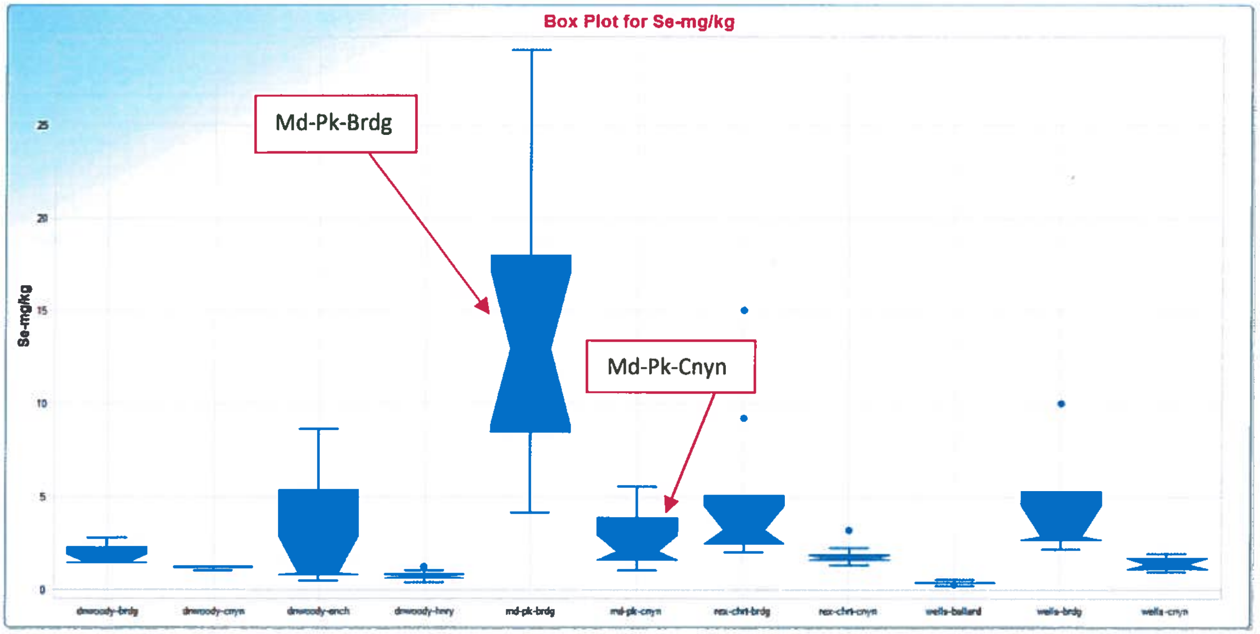

Figure 3. Box Plots Comparing Se in 11 Background/Formation Categories

Table 3. General Statistics for Background Dataset by 11 Categories

General Statistics for Uncensored Data Sets

Variable	NumObs	# Missing	Minimum	Maximum	Mean	SD	SEM	MAD/0.675	Skewness	Kurtosis	CV
Se-mg/kg (dnwoody-brdg)	7	0	1.5	2.8	1.857	0.516	0.195	0	1.262	0.487	0.278
Se-mg/kg (dnwoody-cnyn)	5	0	1.1	1.3	1.22	0.0837	0.0374	0.148	-0.512	-0.612	0.0686
Se-mg/kg (dnwoody-ench)	13	0	0.537	8.63	2.814	2.932	0.813	0.59	1.074	-0.555	1.042
Se-mg/kg (dnwoody-hnry)	13	0	0.477	1.26	0.773	0.198	0.0549	0.138	1.26	2.278	0.256
Se-mg/kg (md-pk-brdg)	13	0	4.2	29	14.6	8.269	2.293	7.413	0.632	-0.55	0.567
Se-mg/kg (md-pk-cnyn)	16	0	1.1	5.5	2.678	1.412	0.353	0.852	0.915	-0.607	0.527
Se-mg/kg (rex-chrt-brdg)	10	0	2.1	15	4.93	4.117	1.302	1.334	2.031	3.877	0.835
Se-mg/kg (rex-chrt-cnyn)	10	0	1.4	3.2	1.85	0.53	0.167	0.222	2.134	5.164	0.286
Se-mg/kg (wells-ballard)	13	0	0.25	0.485	0.369	0.0627	0.0174	0.0563	-0.3	0.302	0.17
Se-mg/kg (wells-brdg)	6	0	2.2	10	4.317	2.989	1.22	0.593	1.848	3.227	0.692
Se-mg/kg (wells-cnyn)	5	0	1	1.9	1.42	0.383	0.171	0.445	0.19	-2.167	0.27

Percentiles for Uncensored Data Sets

Variable	NumObs	# Missing	10%ile	20%ile	25%ile(Q1)	50%ile(Q2)	75%ile(Q3)	80%ile	90%ile	95%ile	99%ile
Se-mg/kg (dnwoody-brdg)	7	0	1.5	1.5	1.5	1.5	2.1	2.22	2.5	2.65	2.77
Se-mg/kg (dnwoody-cnyn)	5	0	1.14	1.18	1.2	1.2	1.3	1.3	1.3	1.3	1.3
Se-mg/kg (dnwoody-ench)	13	0	0.651	0.744	0.816	0.935	5.38	6.142	6.842	7.586	8.421
Se-mg/kg (dnwoody-hnry)	13	0	0.629	0.652	0.666	0.736	0.863	0.87	0.991	1.116	1.231
Se-mg/kg (md-pk-brdg)	13	0	5.52	7.48	8.5	13	18	20.4	27.6	29	29
Se-mg/kg (md-pk-cnyn)	16	0	1.45	1.6	1.6	2.1	3.55	4.6	4.675	4.9	5.38
Se-mg/kg (rex-chrt-brdg)	10	0	2.19	2.44	2.55	3.25	4.825	5.92	9.78	12.39	14.48
Se-mg/kg (rex-chrt-cnyn)	10	0	1.4	1.56	1.6	1.7	1.875	1.96	2.3	2.75	3.11
Se-mg/kg (wells-ballard)	13	0	0.286	0.324	0.355	0.376	0.414	0.416	0.418	0.445	0.477
Se-mg/kg (wells-brdg)	6	0	2.45	2.7	2.725	2.85	4.7	5.3	7.65	8.825	9.765
Se-mg/kg (wells-cnyn)	5	0	1.04	1.08	1.1	1.4	1.7	1.74	1.82	1.86	1.892

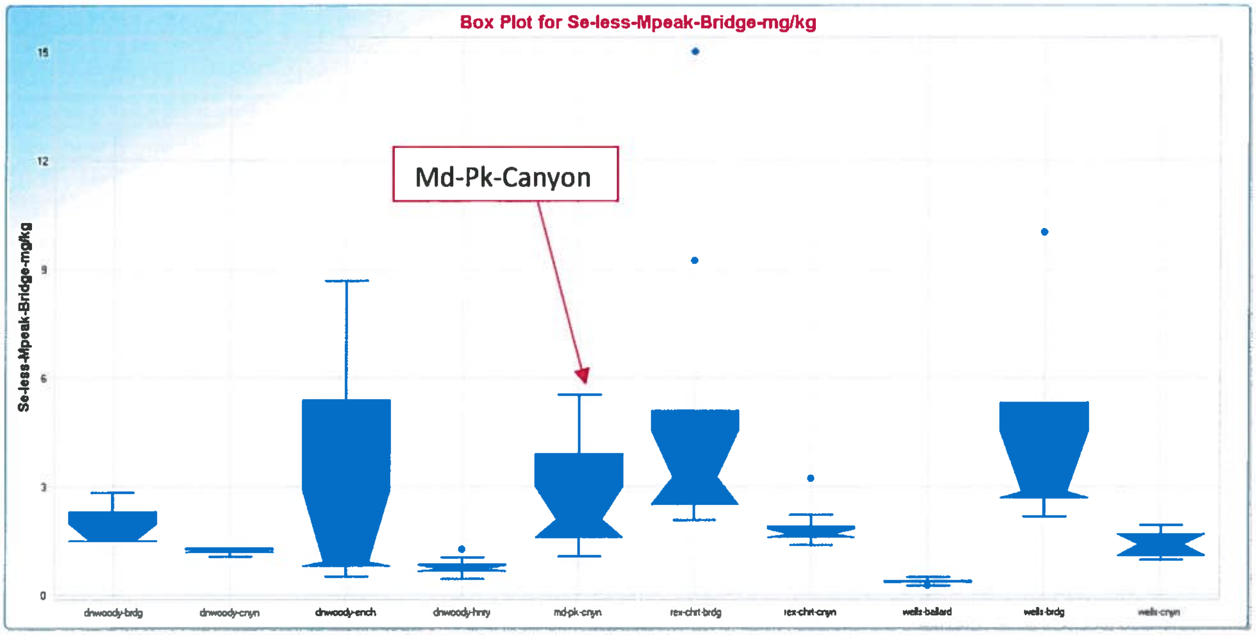

Figure 4. Box Plots Comparing Se in 10 Background/Formation Categories (Excluding Md-Pk-Brdg)

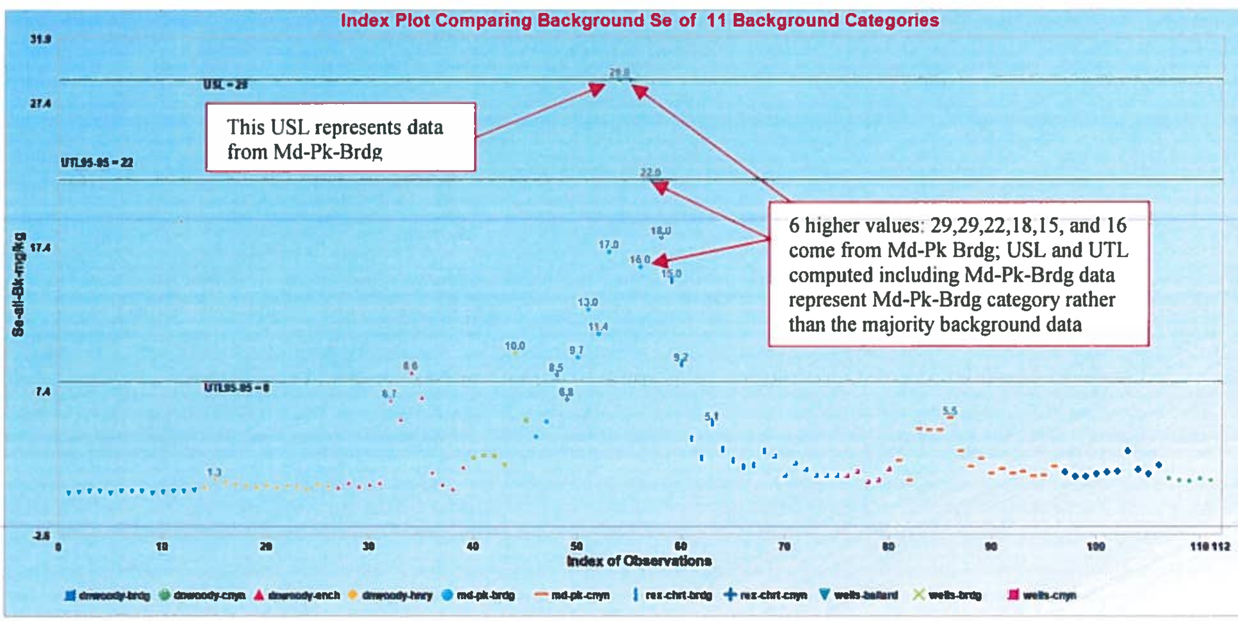

Figure 5. Index Plot Comparing Se in 11 Background/Formation Categories

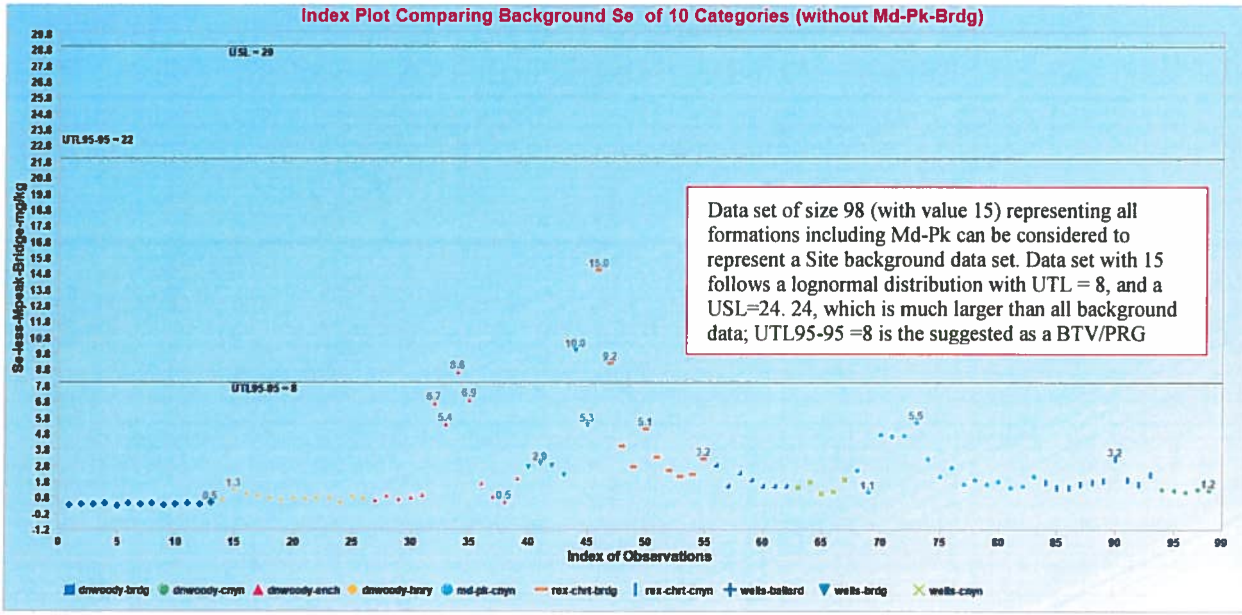

Figure 6. Index Plots Comparing Se in 10 Background/Formation Categories (Excluding Md-Pk-Brdg)

Computations of upper limits used in Figures 5 and 6 are described in Section 3.2. The use of an upper limit such as a USL95, a UTL95-95, or a UCL95 inflated by the inclusion of elevated observations from one background category (e.g., Meade-Peak/Blackfoot Bridge) is not desirable for estimating a BTV/PRG applicable to the entire P4 Mines Site. A PRG should be established based upon a data set representative of the majority of the background area and data set (and not influenced and inflated by a particular area). If deemed necessary, it is suggested that separate PRGs be established for the Mead-Peak formation.

Note: Performing Analysis of Variance (ANOVA) tests to determine if the means/medians of the various categories (e.g., 10 categories) are comparable will not be useful. As can be seen from Figure 4, the means are not comparable. However considering: the difficulties in identify suitable background areas; the presence of inherent variability in the four formations, and that the data ranges of the other 10 background categories (without Meade-Peak/Blackfoot Bridge) are fairly comparable (Figures 4 and 6), it is suggested to use the data set of size 98 from the 10 categories (less Meade-Peak/Blackfoot Bridge) as a site background data set representing the four formations present at the P4 Site.

If the combined data set from the 10 background categories exhibits a fairly continuous display without isolated extreme outliers (inclusion of outliers increases the variability and upper limits) on a Q-Q plot, the combined data set can be considered representative of a background data set, following the removal of the obvious extreme outlier(s). The Q-Q plot displayed in Figure 9 based upon the combined data set of size 97 (without outlier 15) exhibits a fairly continuous display. If the project team wants to establish one PRG for all Site formations, this background data set of size 97 may be used to compute BTV estimates to establish a PRG.

3.1 Suggestions and Preferred Options

The inclusion of data from the Meade-Peak/Blackfoot Bridge category in the computation of upper limits (e.g., USL95, UTL95-95) yields elevated estimates of BTV/PRGs mainly representing the Mead-Peak formation. Such a PRG may not be used for Site areas from the other three formations. Keeping in mind the practical and implementation issues (as discussed above), one of the following options may be used to establish a background data set and compute BTV estimates.

1. Preferred Option: Compute a BTV without using the background data from the Meade-Peak/Blackfoot Bridge category. This BTV, based upon a data set of size 98 (consisting of data from the Meade-Pk/Caldwell Canyon category) or a data set of 97 (without outlying value, 15), represents all four formations and is suitable to establish a single PRG applicable to all four formations of the P4 Mines Site;

2. Compute two upper limits: one upper limit will be used to estimate a BTV/PRG only for the Meade-Peak formation, and the other upper limit will be used to estimate a BTV/PRG for the other three formations. A BTV estimate applicable to the Meade-Peak formation can be computed using the entire background data set of size 111, and a BTV estimate applicable to the other three formations can be computed based upon a data set of size 82 (excluding all Meade-Peak data from both Blackfoot Bridge and Caldwell Canyon areas) representing the other three formations.

3. Due to high variability and presence of outliers, the use of a USL95 is not recommended to estimate a BTV. The commonly used statistic, UTL95-95, is suggested for establishing a BTV/PRG. As described in the ProUCL 5.0 Technical Guide, the use of a USL95 should be avoided when a data set comes from multiple populations (four formations here) and/or consists of outliers. The use of a USL95 inflated by outliers may yield a high number of false negatives which may not be desirable.

   However, if the project team and decision makers determine that background concentrations are naturally high in P4 Mine background areas, they may decide to use a USL95 to estimate a BTV/PRG (without Meade-Peak/ Blackfoot Bridge data).

The reviewer suggests that the first option above be used to establish a background data set, and the use of a UTL95-95 to establish PRGs for point-by-point comparisons. Point-by-point comparisons may be supplemented with a proportion test, with an allowable proportion, $p_0 = 0.05$, of exceedances. There are sufficient (98) background observations collected from the other ten background categories. The category Meade-Peak/ Caldwell Canyon will represent the Meade-Peak formation in the background data set.

3.2 Establishing a Background Data Set Representing the Four Site Formations and Computing Upper Limits to Estimate BTVs/PRGs

The quantile-quantile (Q-Q) plot based upon the entire Se data set of size 111, is shown in Figure 7 and the Q-Q plot of the data set of size 98 without data from category Meade-Peak/Blackfoot Bridge is shown in Figure 8.

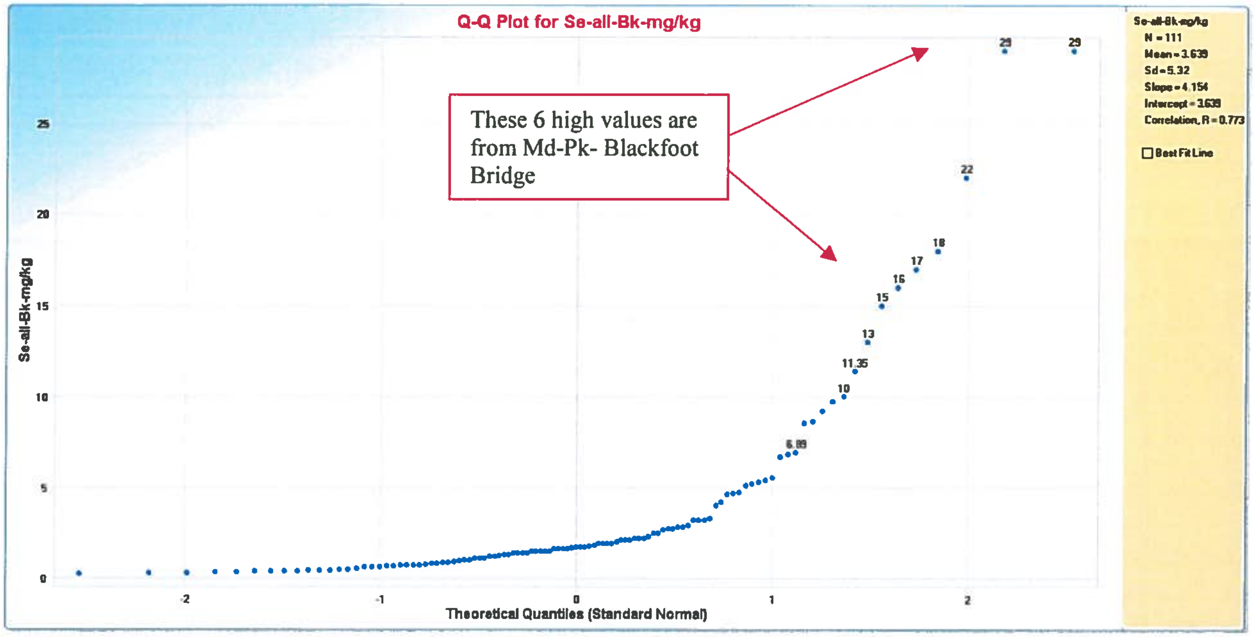

Figure 7. Q-Q Plot Based upon Data Set from 11 Background Categories

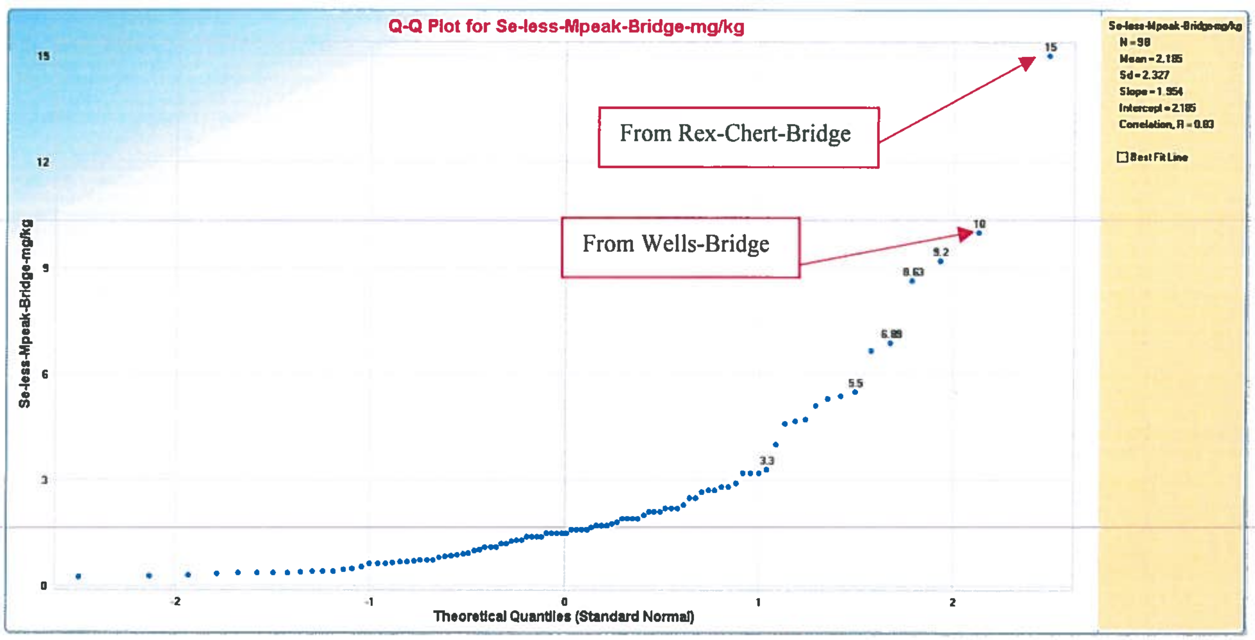

Figure 8. Q-Q Plot Based Upon Data Set from 10 Background Categories without Md-Pk-Brdg

From Figure 8, an obvious outlier, 15 (from Rex-Chert/Blackfoot Bridge category), is observed. The Rosner test identified this value and some other values (8.63, 9.2, and 10) as outliers. These statistical results are not included but can be verified using ProUCL 5.0. Since the concentrations of the COPCs in the four formations are highly variable, only 15 may be considered as an outlier. The full data set of size 111 does not follow a known discernible distribution and the data set of size 98, excluding the Meade-Peak/Blackfoot Bridge data, follows a lognormal distribution. The data set without the outlier 15, also follows a lognormal distribution. The upper limits computed with and without data from the Meade-Peak/Blackfoot Bridge formation (prior to performing outlier tests), respectively, are summarized in Tables 4 and 5. Upper limits based upon the data set of size 97 without the outlier, 15, are summarized in Table 6.

A Q-Q plot shown in Figure 9 is based upon a data set of size 97 without the outlier, 15. The Q-Q plot displayed in Figure 9 represents a fairly continuous graph without breaks of substantial magnitude. The data set displayed in Figure 9 representing the four Site formations (Mead-Peak is represented by data collected from Caldwell Canyon) is the preferred background data set for Se to establish PRGs.

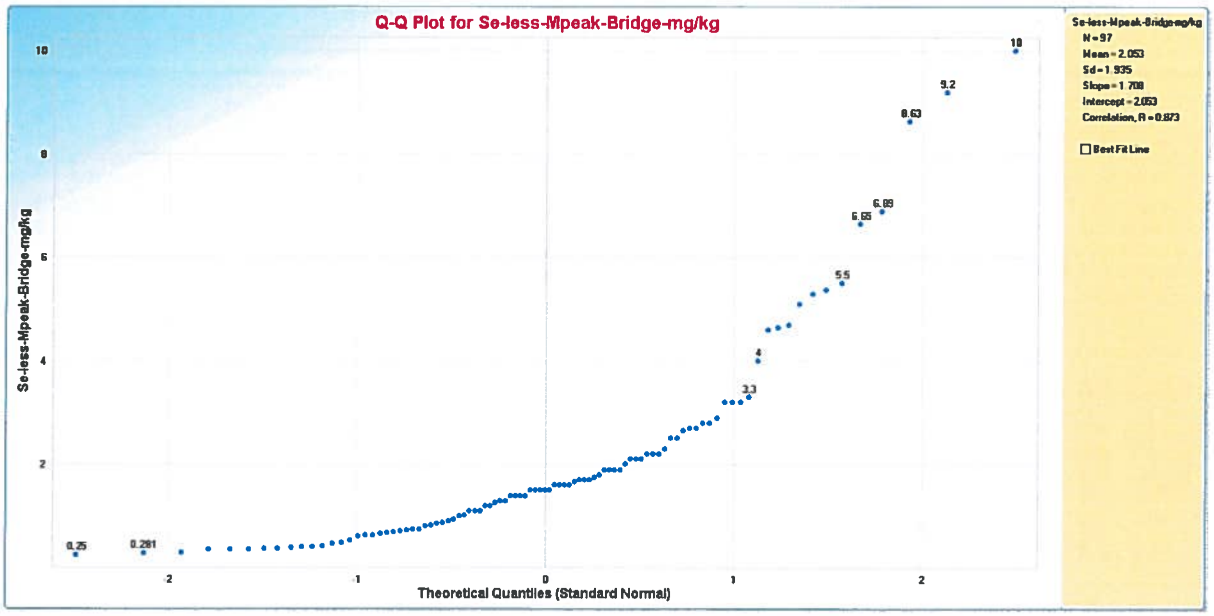

Figure 9. Q-Q Plot Based Upon Se Data Set from 10 Background Categories without Md-Pk-Brdg Data and Without the Isolated Outlier 15.

Table 4. BTV Estimates for Se Based Upon the Full Background Dataset of Size 111

General Statistics			
Total Number of Observations	111	Number of Distinct Observations	82
Minimum	0.25	First Quartile	0.869
Second Largest	29	Median	1.7
Maximum	29	Third Quartile	3.25
Mean	3.639	SD	5.32
Coefficient of Variation	1.462	Skewness	2.983
Mean of logged Data	0.637	SD of logged Data	1.094
Nonparametric Upper Limits for Background Threshold Values			
Order of Statistic, r	109	95% UTL with 95% Coverage	22
Approximate f	1.912	Actual Confidence Coefficient (CC) achieved by UTL	0.92
		Sample Size needed to achieve specified CC	124
95% Percentile Bootstrap UTL with 95% Coverage	20	95% BCA Bootstrap UTL with 95% Coverage	20
95% UPL	16.4	90% Percentile	9.2
90% Chebyshev UPL	19.67	95% Percentile	15.5
95% Chebyshev UPL	26.93	99% Percentile	28.3
95% USL	29		

- Mean = 3.64, Median = 1.7, and
  Nonparametric estimates: UTL95-95=22 or USL=29 of BTV/PRG
- As mentioned earlier, the inclusion of elevated data from the background category, Meade-Peak/Blackfoot Bridge resulted in BTV estimates (22 or 29) representing that category with elevated concentrations rather than representing the majority of background data of size 98 representing the four formations.

Table 5. BTV Estimates for Se Based Upon a Data Set of Size 98 without Mead-Peak/Bridge Data

Se-less-Mpeak-Bridge

General Statistics

Total Number of Observations	98	Number of Distinct Observations	70
Minimum	0.25	First Quartile	0.763
Second Largest	10	Median	1.5
Maximum	15	Third Quartile	2.5
Mean	2.185	SD	2.327
Coefficient of Variation	1.065	Skewness	2.852
Mean of logged Data	0.388	SD of logged Data	0.879
Lognormal GOF Test			
Shapiro Wilk Test Statistic	0.975	**Shapiro Wilk Lognormal GOF Test**	
5% Shapiro Wilk P Value	0.292	Data appear Lognormal at 5% Significance Level	
Lilliefors Test Statistic	0.0583	**Lilliefors Lognormal GOF Test**	
5% Lilliefors Critical Value	0.0897	Data appear Lognormal at 5% Significance Level	
Data appear Lognormal at 5% Significance Level			
Background Statistics assuming Lognormal Distribution			
95% UTL with 95% Coverage	8.022	90% Percentile (z)	4.549
95% UPL (t)	6.397	95% Percentile (z)	6.262
95% USL	24.64	99% Percentile (z)	11.4
Nonparametric Distribution Free Background Statistics			
Data appear Lognormal at 5% Significance Level			
Nonparametric Upper Limits for Background Threshold Values			
Order of Statistic, r	96	95% UTL with 95% Coverage	9.2
Approximate f	1.684	Actual Confidence Coefficient (CC) achieved by UTL	0.873
		Sample Size needed to achieve specified CC	124
95% Percentile Bootstrap UTL with 95% Coverage	9.2	95% BCA Bootstrap UTL with 95% Coverage	9.2
95% UPL	6.977	90% Percentile	4.82
90% Chebyshev UPL	9.203	95% Percentile	6.686
95% Chebyshev UPL	12.38	99% Percentile	10.15
95% USL	15		

- Mean = 2.18; Median = 1.5; Data follow a lognormal distribution
  Statistics based upon a lognormal distribution: UTL95-95 = 8.022; and USL95=24.64
  Most of the upper percentiles: 90%, 95% and 99% are all <=11.4.

- With a mean of 2.18 mg/kg, a 95% percentile of 6.68, and a 99% percentile of 11.15, a BTV estimate of 8.02 (UTL95-95) appears to be more reasonable than 24.64 (USL95).

- The use of a UTL95-95 = 8.02 is recommended to establish a PRG, especially for the three formations: Well, Rex-Chert, and Dinwoody. It is also reasonable to use this PRG=8.02 for the Meade-Peak formation as Mead-Peak formation is represented by the data collected from the Caldwell Canyon background area.

Table 6. BTV Estimates Based Upon the Dataset of Size 97 without Mead-Peak/Blackfoot Bridge Data and Outlier, 15

General Statistics			
Total Number of Observations	97	Number of Distinct Observations	69
		Number of Missing Observations	1
Minimum	0.25	First Quartile	0.745
Second Largest	9.2	Median	1.5
Maximum	10	Third Quartile	2.5
Mean	2.053	SD	1.935
Coefficient of Variation	0.942	Skewness	2.136
Mean of logged Data	0.364	SD of logged Data	0.851

Lognormal GOF Test		
Shapiro Wilk Test Statistic	0.97	**Shapiro Wilk Lognormal GOF Test**
5% Shapiro Wilk P Value	0.155	Data appear Lognormal at 5% Significance Level
Lilliefors Test Statistic	0.0644	**Lilliefors Lognormal GOF Test**
5% Lilliefors Critical Value	0.0902	Data appear Lognormal at 5% Significance Level
Data appear Lognormal at 5% Significance Level		

Background Statistics assuming Lognormal Distribution			
95% UTL with 95% Coverage	7.43	90% Percentile (z)	4.285
95% UPL (t)	5.961	95% Percentile (z)	5.838
95% USL	21.92	99% Percentile (z)	10.43

Nonparametric Distribution Free Background Statistics

Data appear Lognormal at 5% Significance Level

Nonparametric Upper Limits for Background Threshold Values			
Order of Statistic, r	95	95% UTL with 95% Coverage	8.63
Approximate f	1.667	Actual Confidence Coefficient (CC) achieved by UTL	0.869
		Sample Size needed to achieve specified CC	124
95% Percentile Bootstrap UTL with 95% Coverage	8.63	95% BCA Bootstrap UTL with 95% Coverage	8.63
95% UPL	6.674	90% Percentile	4.67
90% Chebyshev UPL	7.889	95% Percentile	5.73
95% Chebyshev UPL	10.53	99% Percentile	9.232
95% USL	10		

- Mean = 2.05; Median = 1.5; Data set follows a lognormal distribution
  Statistics based upon a lognormal distribution are: UTL95-95 = 7.43 and USL95=21.92

- With a mean of 2.05 mg/kg, 95% percentile of 5.83, and a 99% percentile of 10.43, a BTV estimate of 7.43 (UTL95-95) appears to be more reasonable than 21.43 (USL95).

- The use of UTL95-95 =7.43 is suggested to establish a PRG for Se. This PRG is applicable to all four formations present at the P4 Mines Site.

Recommendations: Considering the presence of several formations and difficulties associated with the identification of an appropriate background data set, it is suggested that 8.02 mg/kg or 7.43 mg/kg be used as an estimate of PRG for at least three formations. Since concentrations of the Meade-Peak formation of the Caldwell Canyon are in the range comparable to ranges of the other nine background categories. The use the same PRG of 8 mg/kg is suggested for all four formations present at the P4 Site.

3.3 Index Plots to Compare Onsite Data with Background Data and BTVs/PRGs

Mr. Tomten has indicated that once PRGs have been established for the COPCs, they would like to use formal index plots to perform site versus background comparisons and compare onsite values with those PRGs. A formal color-coded (symbol-coded) index plot represents a useful tool to compare onsite data with background data and PRGs. Index plots are also useful to determine if the established background data set indeed represents a background data set. Distances of onsite observations (from the various mine/formation combinations) from the potential PRGs displayed on an index plot can help the project team in selecting an appropriate upper limit to establish a PRG, and also in making cleanup/remediation decisions at the sampled locations represented by onsite observations displayed on the index plot.

Several index plots are generated comparing onsite data from the three P4 Mines with the established background data and BTV/PRG estimates. The background data set of size 98 (with value 15) used in the following index plots consists of all data except for the Meade-Peak/Blackfoot Bridge category data. For comparison purposes, other upper limits including: 29 mg/kg (nonparametric USL based upon all 111 background values); 22 mg/kg (nonparametric UTL95-95 based upon all 111 background values); and 8 mg/kg (lognormal UTL95-95 based upon a data set of 98 without Meade-Peak/Blackfoot Bridge category) are displayed on the index plots presented in this section.

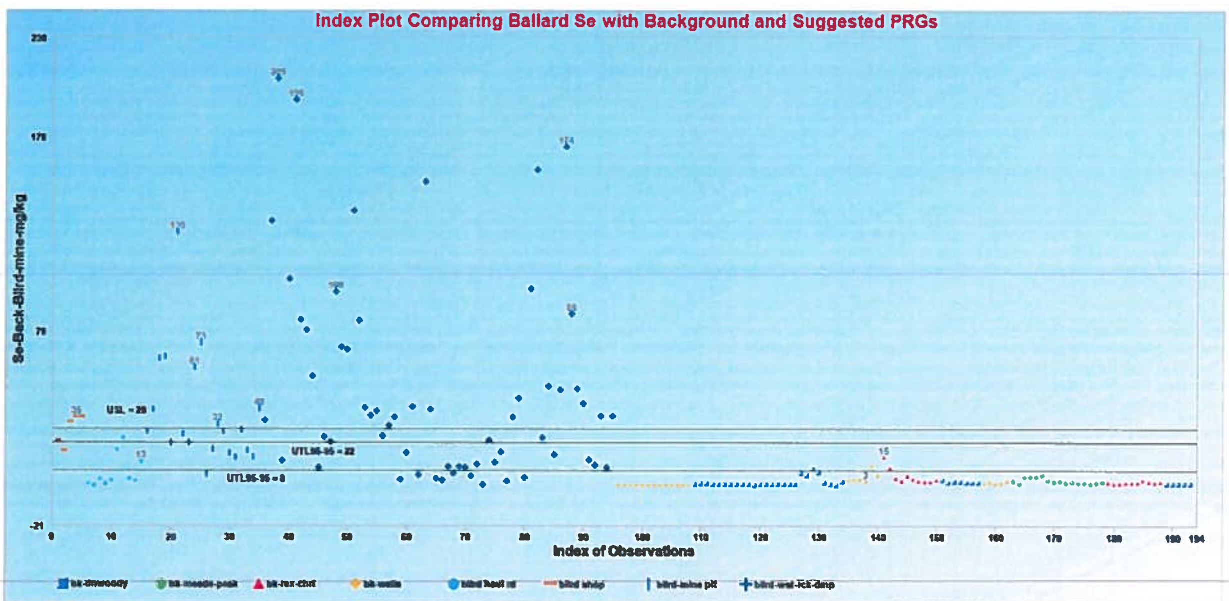

Figure 10. Index Plot Comparing Ballard Mine Se Data with Background Data from Four Formations and BTV Estimates

Figure 10 has the background data from the four color-coded background formations (irrespective of their origin) and onsite data from the four areas (Haul Road, Ballard Shop, Mine Pits and Waste-Rock Dumps) of the Ballard Mine. It is easy to note that Se concentrations of the four background categories are fairly comparable. From Figure 10, it is observed that the Ballard Waste-Rock Dump areas exhibit significantly higher Se concentrations than the background data and the three BTVs displayed in Figure 10. Several observations from Ballard Shop and Ballard Mine pits also exceed the BTV/PRG estimates. Ballard Haul Road exhibits the lowest levels of Se concentrations.

Since the background concentrations from the four formations are comparable, the entire background data has been labeled as Bk/bk in most of the index plots displayed as follows.

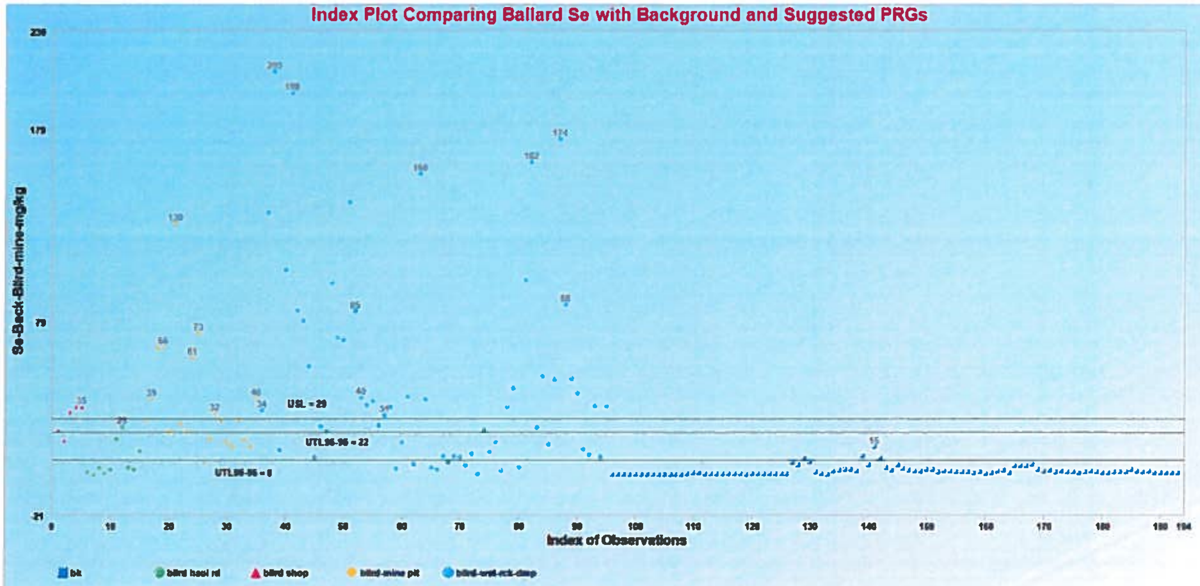

Figure 11. Index Plot Comparing Ballard Mine Se Data with Background (bk) Data (including 15) and BTV Estimates

Figure 11 depicts an index plot similar to the index plot shown in Figure 10, except that all background formation categories are merged into one category, labeled as Bk. It is of interest to identify mine pits (two of them) and waste dumps (six of them) exhibiting higher concentrations in comparison with background areas and other Ballard mine areas. Figure 12 has a color-coded (symbol-coded) index plot comparing Se concentrations of the various waste-rock dumps and mine-pits with background data and potential BTV/PRGs. A review of Figure 12 can help the project team in quickly identifying Ballard mine areas exhibiting substantially higher Se concentrations in comparison with background data and BTV/PRG estimates.

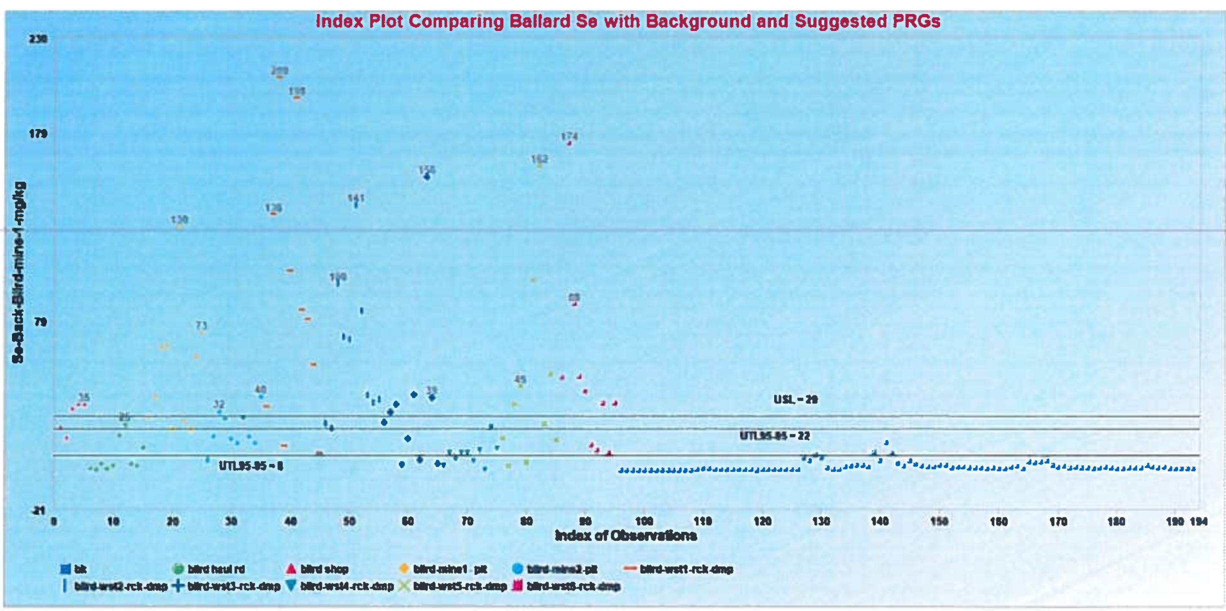

Figure 12. Index Plot Comparing Ballard Mine Se Data Categorized by Waste Dumps and Mine Pits with Background Data (including 15) and BTV Estimates

Figure 13 has an index plot similar to the index plot shown in Figure 10, comparing Se concentrations from Henry Mine and background areas.

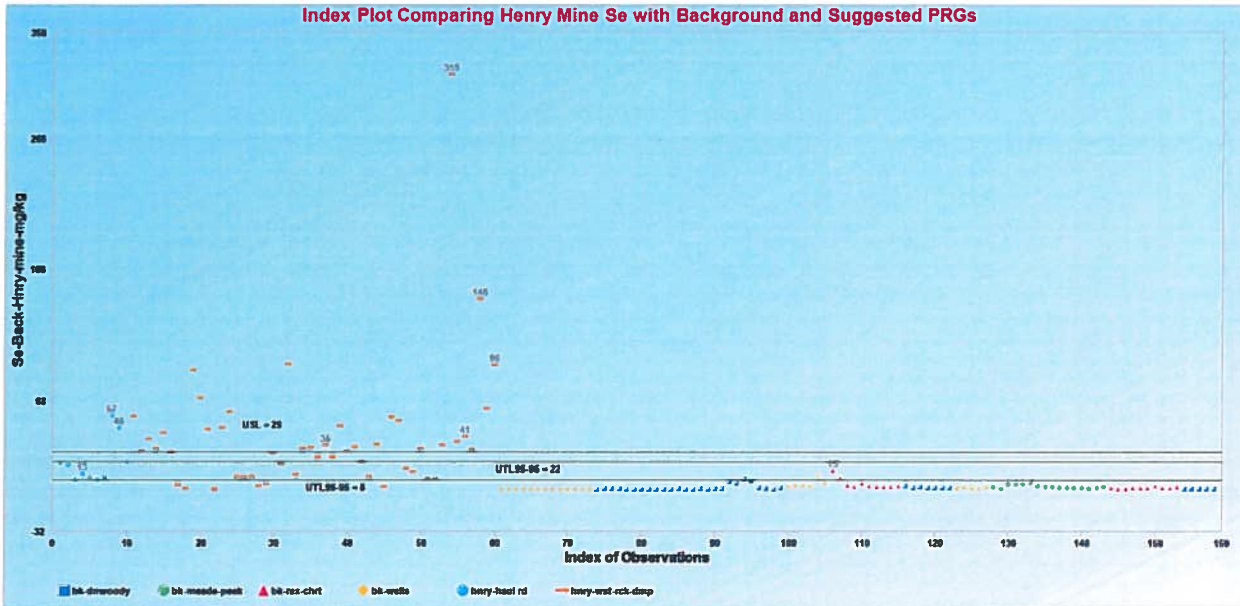

Figure 13. Index Plot Comparing Henry Mine Se Data with Background Data from Four Formations and BTV Estimates

From Figure 13, it is easy to see that Waste-Rock-Dumps in Henry mine areas exhibit significantly higher Se concentrations in comparison with the background and PRGs. To identify the waste-rock dump areas exceeding BTV values, one can use an index plot displaying data individually from the waste-rock dump as shown in Figure 14.

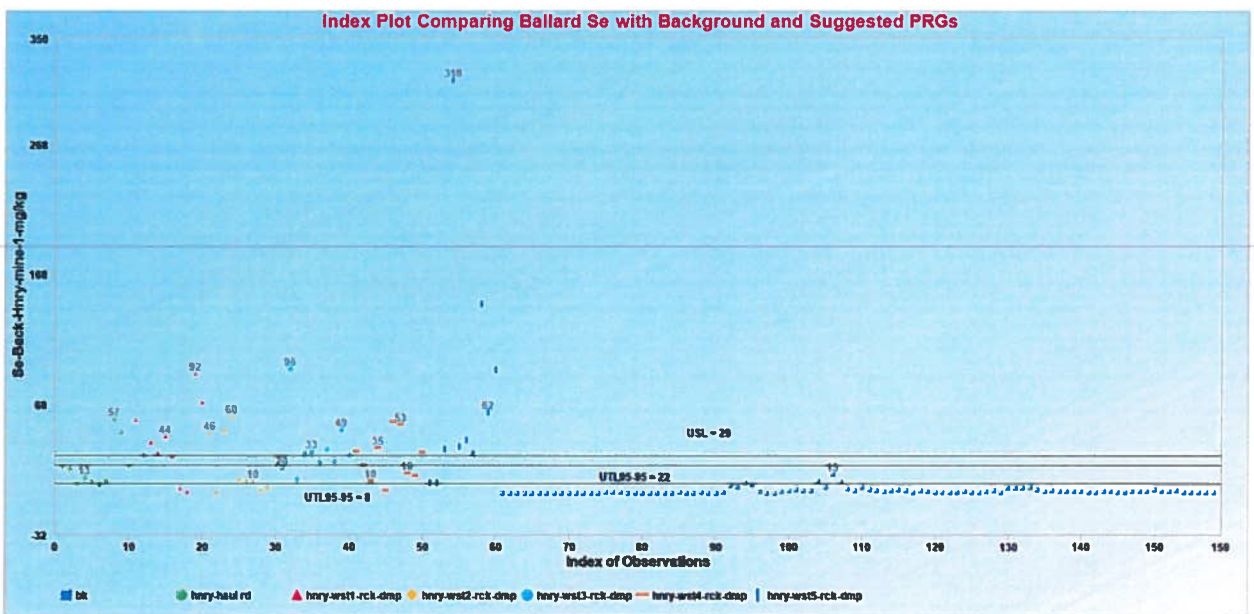

Figure 14. Index Plot Comparing Henry Mine Se Data Categorized by Waste Dumps with Background Data (including 15) and BTV Estimates

A quick review of Figure 14 can help the project team in identifying Henry mine-dump areas exhibiting substantially higher Se concentrations in comparison with background data and BTV/PRG estimates. It is easy to note that wst5-rck-dmp exhibits the highest of Se concentrations followed by wst3-rck-dmp and wst1-rck-dmp.

Figure 15 and Figure 16 have similar index plots comparing Se concentrations from Enoch Valley Mine with those of background areas and BTV/PRG estimates.

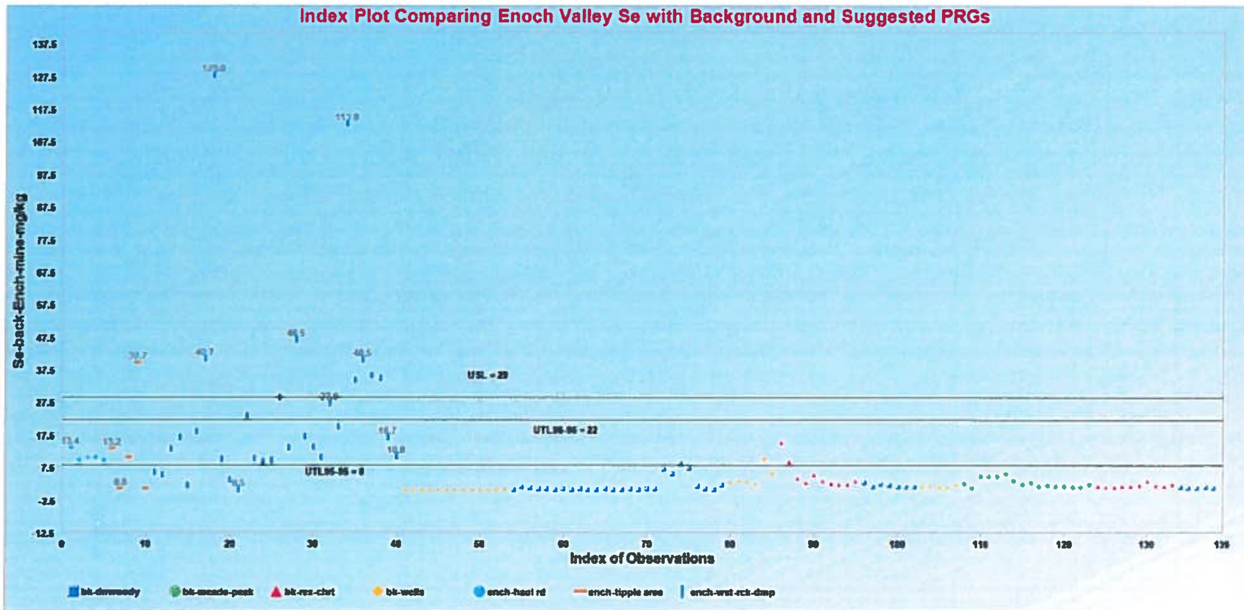

Figure 15. Index Plot Comparing Enoch Valley Se Data with Background Data from Four Formations and BTV Estimates

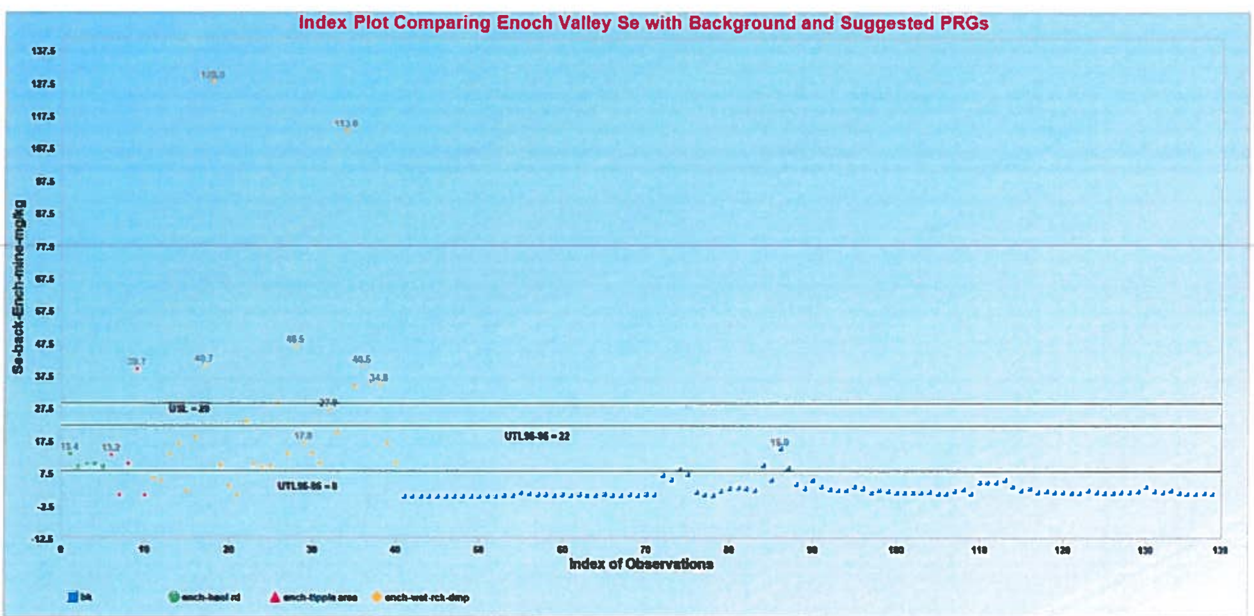

Figure 16. Index Plot Comparing Enoch Valley Se Data with Background Data (including 15) and BTV Estimates

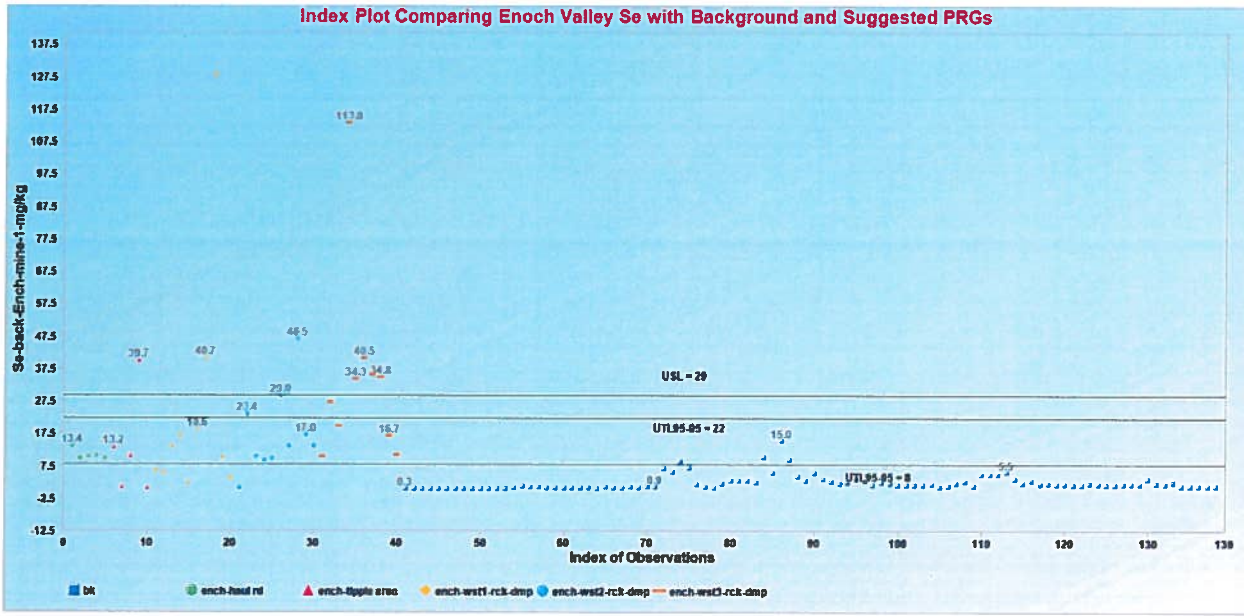

Figure 17. Index Plot Comparing Enoch Valley Se Data Categorized by Waste Dumps with Background Data (including 15) and BTV Estimates

A review of displays presented in Figures 16 and 17 reveals that Se concentrations from waste-rock dump 3 exhibits substantially higher Se concentrations in comparison with background data and BTV/PRG estimates followed by wst1-rck-dmp and wst2-rck-dmp.

4.0 Comparing Se Data Collected During Years 2009 and 2014

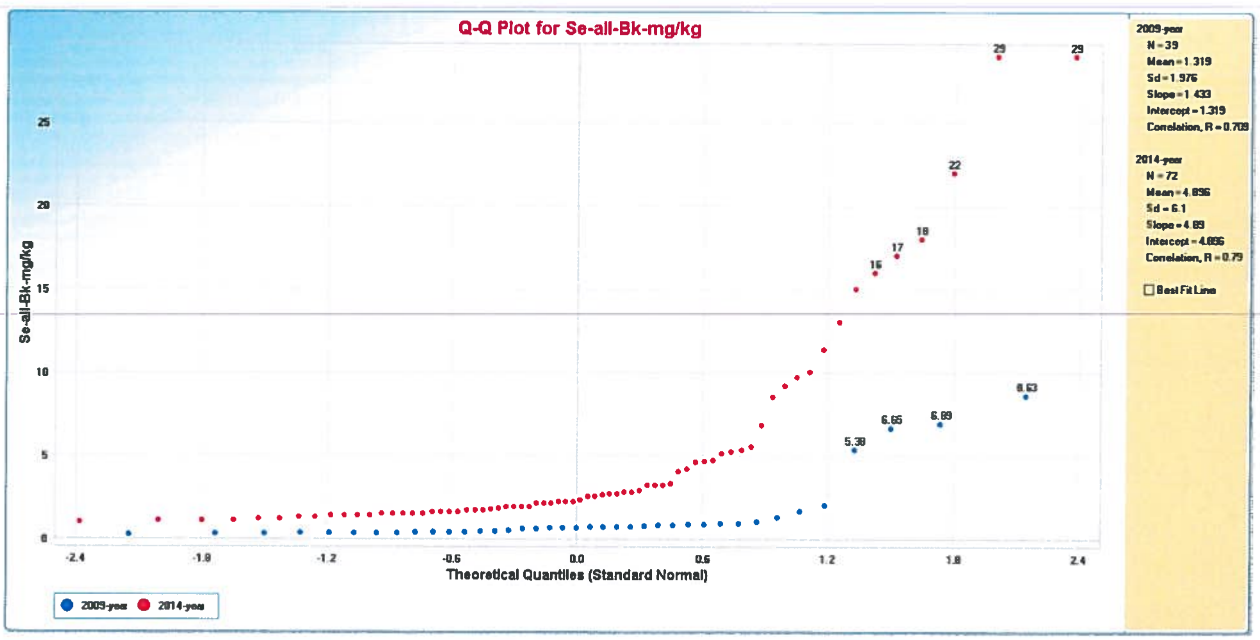

Figure 18. Q-Q plots comparing two Se background data sets collected during 2009 and 2014

From Figure 18, it is easy to see that there are differences (also determined by the WMW test) in the Se background concentrations collected during 2009 and 2014. Using the year 2009 background data, it is noted that Se concentrations do not follow a discernible distribution. Nonparametric upper limits computed using the 2009 data are shown in Table 7. From Table 7, it is noted that a nonparametric USL95 = 8.63 mg/kg. However, in the Excel sheet, "PRG-Table-Ballard-FS-with Updated BTVs.xlsx," provided by R10, a USL95 of 1.80 mg/kg has been listed for Se computed using the 2009 data. Even though a Se value of 1.80 mg/kg may appear to be lower than site background, a BTV estimate of 8.63 mg/kg does not.

In this Excel sheet some weighted BTV estimates have also been listed. For example, a weighted BTV estimate based upon the entire background data set (from 2009 and 2014) for Se has been listed as 16.2 mg/kg. The validity of the estimates of weights assigned to the various formations and therefore, of a BTV estimate computed using those weights is questionable. The project team may want to investigate these issues (e.g., weight assignments) further.

Table 7. Upper Limits for Se Computed using 2009 Data

Se-all-Bk-mg/kg (2009-year)			
General Statistics			
Total Number of Observations	39	Number of Distinct Observations	39
Minimum	0.25	First Quartile	0.416
Second Largest	6.89	Median	0.677
Maximum	8.63	Third Quartile	0.896
Mean	1.319	SD	1.976
Coefficient of Variation	1.498	Skewness	2.758
Mean of logged Data	-0.255	SD of logged Data	0.877
Nonparametric Upper Limits for Background Threshold Values			
Order of Statistic, r	39	95% UTL with 95% Coverage	8.63
Approximate f	2.053	Actual Confidence Coefficient (CC) achieved by UTL	0.865
		Sample Size needed to achieve specified CC	59
95% Percentile Bootstrap UTL with 95% Coverage	8.63	95% BCA Bootstrap UTL with 95% Coverage	8.63
95% UPL	6.89	90% Percentile	2.676
90% Chebyshev UPL	7.322	95% Percentile	6.674
95% Chebyshev UPL	10.04	99% Percentile	7.969
95% USL	8.63		

The Se data set collected during 2014 (without Meade-Peak/Blackfoot Bridge data with elevated values) does not follow a discernible distribution. Therefore, a USL95 will default to the largest value, 15 in the data set. Table 8 has upper limits computed using 2014 data without the Meade-Peak/Blackfoot Bridge data. Statistics summarized in Table 8 do not use the lower Se background concentrations (as shown in Figure 18) collected during the year 2009; therefore the limits summarized in Table 8 are biased high.

Table 8. Upper Limits for Se Computed using 2014 Data

Se-all-Bk-mg/kg-less-md-pk-brdg-2014			
General Statistics			
Total Number of Observations	59	Number of Distinct Observations	31
Minimum	1	First Quartile	1.5
Second Largest	10	Median	1.9
Maximum	15	Third Quartile	2.85
Mean	2.758	SD	2.379
Coefficient of Variation	0.863	Skewness	3.292
Mean of logged Data	0.813	SD of logged Data	0.572
Nonparametric Upper Limits for Background Threshold Values			
Order of Statistic, r	58	95% UTL with 95% Coverage	10
Approximate f	1.526	Actual Confidence Coefficient (CC) achieved by UTL	0.801
		Sample Size needed to achieve specified CC	93
95% Percentile Bootstrap UTL with 95% Coverage	10.5	95% BCA Bootstrap UTL with 95% Coverage	10.5
95% UPL	9.2	90% Percentile	4.78
90% Chebyshev UPL	9.957	95% Percentile	5.87
95% Chebyshev UPL	13.22	99% Percentile	12.1
95% USL	15		

Suggestions: It is suggested to clarify/determine the source of the discrepancy (1.80 versus 8.63) in BTV estimates computed using the 2009 data; and establish the validity of the weights used to compute weighted BTV estimates. Even though a Se value of 1.80 mg/kg may appear to be lower than site background, a BTV estimate of 8.63 mg/kg does not appear to be lower than the site background. As computed earlier and summarized in Tables 5 and 6, a BTV/PRG for Se should be computed based upon a balanced background data set collected during 2009 and 2014 representing all formations and not influenced by observations collected from a single background category (e.g., Meade-Peak/Blackfoot Bridge).

References

Singh, A. and Nocerino, J.M. 1995. *Robust Procedures for the Identification of Multiple Outliers*. Handbook of Environmental Chemistry, Statistical Methods, Vol. 2.G, pp. 229-277. Springer Verlag, Germany.

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http://www.epa.gov/nerlesd1/databases/datahome.htm

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http://www.epa.gov/esd/databases/scout/abstract.htm

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APPENDIX C-8

A/T Additional Comments on Ballard ARARs

Transmitted to P4 on February 17, 2016

From:	Tomten, Dave
To:	Barry Myers (bmyers@blm.gov); Bruce Narloch; Bruce Olenick; Cary Foulk (cfoulk@integrated-geosolutions.com); Celeste Christensen; Colleen O"Hara-Epperly; COOPER, RANDALL LEE [AG/1000]; Tomten, Dave; Dennis Smith (dennis.smith2@ch2m.com); Eldine Stevens; Emily Yeager; Gary Billman; Jeff Cundick; Jeff Schut; Jeremy Moore (jeremy_n_moore@fws.gov); Wallace, Joe; Kelly Wright; Leah Wolf Martin (leah@wolfmartininc.com); LEATHERMAN, CHRIS R [AG/1850]; Edmond, Lorraine; Michael Rowe; Norka Paden (Norka.Paden@deq.idaho.gov); PRICKETT, MOLLY [AG/1850]; Randy Vranes; Sandi Fisher; Shannon Leigh Ansley (sansley@sbtribes.com); Shephard, Burt; Stifelman, Marc; Stumbo, Sherri A -FS; susanh@ida.net; Trina Burgin; Vance Drain
Subject:	Ballard ARARs
Date:	Wednesday, February 17, 2016 2:54:57 PM

Molly, all –

As we have discussed during our bi-weekly calls, there have been several iterations of the ARAR summary table for tech memo #1 for the Ballard project. Your team has been waiting for me to provide final comments and direction on this matter for some time, so that TM #1 may be finalized. In particular, we have been evaluating potential ARARs for radiologically contaminated materials and coordinating with our HQ office and another Region. Below are final comments and direction on ARARs for radiologically contaminated materials, and some additional clarifying comments on several other ARARs.

1. In Table 3-1, the UMTRCA standard at 40 CFR 192.02(a) should be identified as RAR. This is a design standard that specifies that the control of residual radioactive materials shall be designed to be effective for at least 200 years.
2. The following regulations and standards that pertain to radiologically contaminated materials should be deleted and not identified as potentially ARAR or TBC: other standards at 40 CFR Part 192 (other UMTRCA standards); 10 CFR Part 20 (NRC standards); 10 CFR Part 61 (DOE licensing requirements); and 40 CFR Part 61 (NESHAPs requirements). Rather, cleanup decisions will be based on site-specific risk-based cleanup levels or background, and other ARARs such as MCLs and surface water standards, and other factors. Update Table 3-1 to reflect this direction.
3. Table 3-1 lists both the SDWA and implementing regulations. Delete the row identifying the SDWA as potentially ARAR, as this is overly broad. Retain the reference to the regulation, and cite the specific section(s) of the regulations that provide substantive standards for this site, and list the contaminants, rather than the entire Part.
4. Similarly for water quality standards, delete the row in Table 3-1 identifying the CWA as potentially ARAR (as you proposed), as this is overly broad. Retain the reference to the regulation, and cite the specific section(s) and contaminants for which FWQC are being identified as potentially ARAR.
5. In Table 3-1 delete row identifying national secondary drinking water regulations as TBC.
6. In Table 3-1, additional specificity is needed for identifying potential RCRA ARARs. Add a row identifying RCRA Subtitle D standards at 40 CFR 257 as potentially RAR to remedial actions that involve consolidation of mine wastes in repositories or beneath protective barriers. These regulations include certain criteria that are required to be met my solid waste disposal facilities and practices, such as not restricting base flow of the flood plain, not taking threatened or endangered species, and not causing a discharge to navigable waters. Also add a row adding RCRA Subtitle D standard at 40 CFR 258 as potentially RAR to remedial actions that involve the consolidation of mine wastes in repositories or beneath protective barriers. These regulations provide criteria for cover material, run-on/runoff control systems, access control, and liquid restrictions. (Model language can be found in

the ROD Amendment, Upper Basin Coeur d'Alene River, Bunker Hill Superfund Site, Table 13-3, to be forwarded separately.)

7. In Table 3-2 (and again in Table 3-4), the Area Wide Risk Management Plan is identified as potentially TBC. It should be noted that this document includes recommendations on many issues, including monitoring, trigger and action levels, and other matters. References to use of this of document to develop action levels should be deleted (as we have not used this document to help establish PCLs).
8. In Table 3-3, the Federal Land Policy and Management Act and implementing regulations are cited as potentially applicable. Please provide greater specificity in the citation/reference.
9. In Table 3-3, please retain the NAGPRA as a potentially RAR.

Please let me know if you would like to discuss any of these comments. It's my understanding that resolution of this issue will allow TM #1 to now be finalized.
Dave

____

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APPENDIX C-9

P4 Response to A/T Additional Comments (dated February 17, 2016) on Ballard ARARs

Submitted to A/T on March 9, 2016

Leah Wolf Martin

From: Vance Drain <Vance.K.Drain@mwhglobal.com>
Sent: Wednesday, March 09, 2016 8:15 AM
To: Tomten.Dave@epamail.epa.gov
Cc: MOLLY PRICKETT [AG/1850]; Leah Wolf-Martin (leah@wolfmartininc.com); COOPER, RANDALL LEE [AG/1000]
Subject: Revised ARAR Tables 3-1 to 3-4 and RTCs
Attachments: P4 RTCs on ARARs and revised ARAR Tables (03-08-16).pdf

Hi Dave,
Attached are P4's responses to A/T comments (dated February 17, 2016) on the revised ARAR table that we originally sent to you on 7/30/15.
Please distribute this document to the other A/Ts, and let us know if you have any questions with regard to our responses or the revised ARAR tables (second revision).
Best Regards,
Vance

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P4's Responses to A/T Ballard ARAR Comments dated February 17, 2016

on the

Feasibility Study Technical Memorandum for P4's Ballard Mine Draft Revision 0, March 2015

Specific Comments

SC#1. In Table 3-1, the UMTRCA standard at 40 CFR 192.02(a) should be identified as RAR. This is a design standard that specifies that the control of residual radioactive materials shall be designed to be effective for at least 200 years.

> ***P4 Response (SC#1):*** *Although P4 does not agree that UMTRCA applies to the Ballard Site, 40 CFR 192.02(a) has been identified as potentially RAR in Table 3-1.*

SC#2. The following regulations and standards that pertain to radiologically contaminated materials should be deleted and not identified as potentially ARAR or TBC: other standards at 40 CFR Part 192 (other UMTRCA standards); 10 CFR Part 20 (NRC standards); 10 CFR Part 61 (DOE licensing requirements); and 40 CFR Part 61 (NESHAPs requirements). Rather, cleanup decisions will be based on site-specific risk-based cleanup levels or background, and other ARARs such as MCLs and surface water standards, and other factors. Update Table 3-1 to reflect this direction.

> ***P4 Response (SC#2)****: Agreed. The regulations and standards listed above have been removed from Table 3-1.*

SC#3. Table 3-1 lists both the SDWA and implementing regulations. Delete the row identifying the SDWA as potentially ARAR, as this is overly broad. Retain the reference to the regulation, and cite the specific section(s) of the regulations that provide substantive standards for this site, and list the contaminants, rather than the entire Part.

> ***P4 Response (SC#3)****: Agreed. The SDWA and the specific sections(s) have been removed from Table 3-1. A reference to COCs/COECs (in Table 3-6) has been included in the Water Quality Standards row (please refer to edited Table 3-1).*

SC#4. Similarly for water quality standards, delete the row in Table 3-1 identifying the CWA as potentially ARAR (as you proposed), as this is overly broad. Retain the reference to the regulation, and cite the specific section(s) and contaminants for which FWQC are being identified as potentially ARAR.

> ***P4 Response (SC#4)****: Agreed. The CWA has been removed from Table 3-1 and the specific sections(s) and a reference to COCs/COECs in Table 3-6 have been included.*

SC#5. In Table 3-1 delete row identifying national secondary drinking water regulations as TBC.

> ***P4 Response (SC#5)****: Agreed. The National Secondary Drinking Water Regulation have been removed as TBC from Table 3-1.*

SC#6. In Table 3-1, additional specificity is needed for identifying potential RCRA ARARs. Add a row identifying RCRA Subtitle D standards at 40 CFR 257 as potentially RAR to remedial actions that involve consolidation of mine wastes in repositories or beneath protective barriers. These regulations include certain criteria that are required to be met my solid waste disposal facilities and practices, such as not restricting base flow of the flood plain, not taking threatened or endangered species, and not causing a discharge to navigable waters. Also add a row adding RCRA Subtitle D standard at 40 CFR 258 as potentially RAR to remedial actions that involve the consolidation of mine wastes in repositories or beneath protective barriers. These regulations provide criteria for cover material, run-on/runoff control systems, access control, and liquid restrictions. (Model language can be found in the ROD Amendment, Upper Basin Coeur d'Alene River, Bunker Hill Superfund Site, Table 13-3, to be forwarded separately.)

> ***P4 Response (SC#6)**: A reference to 40 CFR 257 has been included in Table 3-3 (vs Table 3-1) as these criteria are location/action specific. P4 does not agree that 40 CFR 258, requirements for Municipal Solid Waste Landfills and thus related design requirements are potentially RAR to the Ballard Site. These requirements have not been included in the tables.*

SC#7. In Table 3-2 (and again in Table 3-4), the Area Wide Risk Management Plan is identified as potentially TBC. It should be noted that this document includes recommendations on many issues, including monitoring, trigger and action levels, and other matters. References to use of this of document to develop action levels should be deleted (as we have not used this document to help establish PCLs).

> ***P4 Response (SC#7)**: The Area-Wide Risk Management has been deleted from Table 3-2 as the action levels in the plan were not used to develop PCLs. It has been left as TBC in Table 3-4 and the description revised to remove reference to action levels.*

SC#8. In Table 3-3, the Federal Land Policy and Management Act and implementing regulations are cited as potentially applicable. Please provide greater specificity in the citation/reference.

> ***P4 Response (SC#8):** Table 3-3 has been revised to change the citation to 43 U.S.C. §§ 1732 et seq. and includes a revised description and site-specific comments.*

SC#9. In Table 3-3, please retain the NAGPRA as a potentially RAR.

> ***P4 Response (SC#9)**: P4 does not agree that the NAGPRA is potentially RAR because P4 is not a federal agency or institution and because the Ballard Site boundaries do not include federal or tribal lands. P4 proposes to remove this regulation as shown in Table 3-3.*

BALLARD MINE SITE: POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The following table presents a list of requirements tentatively identified by P4 Production, L.L.C. ("P4") as potential Applicable or Relevant and Appropriate Requirements ("ARARs") for the Ballard Mine Site pursuant to an Administrative Settlement Agreement and Order on Consent for Performance of Remedial Investigation and Feasibility Study at the Enoch, Henry, and Ballard Mine Sites in Southeastern Idaho dated September 28, 2009. P4 anticipates that this list of potential ARARs will be used in preparing the Feasibility Study for the Ballard Mine, including for the development of preliminary remediation goals and for use as threshold criteria against which remedial alternatives will be evaluated. P4 acknowledges that the following list of potential ARARs are not binding and that final ARARs will be developed by EPA and set forth in the Record of Decision for use as performance standards for the remedial design and remedial action.

Statutes and regulations, and their citations, included in the tables included below are provided as headings to identify general categories of potential ARARs for the convenience of the reader. Listing the statutes and regulations does not indicate acceptance of the entire statute or regulation as potential ARARs; rather only the substantive provisions of the requirements cited in these tables are potential ARARs.

Table 3-1: Federal Chemical Specific ARARs for the Ballard Site

	Statutes, Regulations, Standards, or Requirements	Citations or References	General Description	Site-Specific Comments	Determination
~~1~~	~~Safe Drinking Water Act~~	~~42 U.S.C. §§ 300(f) *et seq.*~~	~~Protection of public water systems and underground sources of drinking water.~~	~~Potentially relevant and appropriate if groundwater beneath the Site is used to supply public water systems.~~	~~Potentially relevant and appropriate~~
~~2~~1	National Primary Drinking Water Regulations	40 C.F.R. Part 141	Establishes health-based standards (maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs)) for public water systems.	Potentially relevant and appropriate if groundwater beneath the Site is used to supply public water systems. COCs/COECs and proposed groundwater cleanup levels are provide in Table 3-6.	Potentially relevant and appropriate
~~3~~2	Water Quality Standards[1]	33 U.S.C. § 1314(a) 40 C.F.R. Part 131	Section 304 of the federal Clean Water Act (33 U.S.C. § 1314) requires that individual states establish water quality standards for surface waters. The implementing regulation establishes the Ambient Water Quality Criteria, which are the minimum requirements for state water quality standards that are protective of aquatic life. Under CERCLA, water quality criteria for the protection of aquatic life are considered relevant and appropriate for actions that involve surface waters or groundwater discharges to surface waters. The federal water quality standards are developed for states to use in development of water quality criteria that incorporate designated uses for specific surface water bodies. The State of Idaho has adopted the federal water quality criteria. Where numeric state water quality standards have not been promulgated, federal numeric water quality standards are considered relevant and appropriate standards. Federal Ambient Water Quality Criteria have been established for short-term exposures (acute criteria) and for long-term exposures (chronic criteria) for protection of aquatic biota.	The State of Idaho has adopted the federal water quality criteria. Where numeric state water quality standards have not been promulgated, federal numeric water quality standards are considered applicable. COCs/COECs and proposed surface water cleanup levels are provide in Table 3-6.	Applicable

Commented [A1]: Deleted per EPA SC#3

Commented [A2]: Revised per EPA SC#3

Commented [A3]: Revised per EPA SC#4

[1] National Recommended Water Quality Criteria are available at http://www.epa.gov/ost/criteria/wqctable/.

Table 3-1: Federal Chemical Specific ARARs for the Ballard Site

	Statutes, Regulations, Standards, or Requirements	Citations or References	General Description	Site-Specific Comments	Determination
~~4~~3	Resource Conservation and Recovery Act	40 C.F.R. § 261.4(b)(7)	EPA exempts mining wastes from the extraction, beneficiation, and some processing of ores and minerals, in accordance with the Bevill amendment to RCRA.	Waste rock at the Site may meet this exemption.	Applicable
~~5~~4		40 C.F.R. § 261.20	Generators of solid waste must determine whether the waste is hazardous. A solid waste is hazardous if it exhibits the toxicity characteristic (based on extraction procedure Method 1311).	Potentially applicable depending on the selected remedy.	Applicable
~~6~~	~~National Secondary Drinking Water Regulations~~	~~40 C.F.R. § Part 143~~	~~Establishes non-mandatory, secondary drinking water standards (secondary MCLs) primarily for aesthetic considerations in public water supply systems~~	~~Potentially relevant and appropriate if groundwater beneath the Site is used to supply public water systems.~~	~~TBC~~
~~7~~5	Uranium Mill Tailings Radiation Control Act (UMTRCA)— Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings	42 U.S.C. §§ 7901 *et seq.* 40 C.F.R. Part 192.02 (a)	~~Groundwater and soil concentration limits applicable to the uranium and thorium mill tailings sites identified under the UMTRCA statute.~~Control of residual radioactive materials and their listed constituents will be designed to be effective for at least 200 years.	~~The Ballard Mine is not a uranium mine and no processing of uranium has occurred at the Ballard Mine. Uranium at the Ballard Mine is naturally occurring and is present in the waste rock. As such uranium and its daughter products are radionuclides of concern (ROCs).~~ Potentially relevant and appropriate remedial design criteria for the naturally occurring uranium and daughter products at the Ballard Mine.	Potentially relevant and appropriate~~TBC~~
~~8~~	~~Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination~~	~~OSWER No. 9200.4-18, August 22, 1997~~	~~Clarifying guidance for establishing protective cleanup levels for radioactive contamination at CERCLA sites. Attachment A lists likely federal ARARs for Superfund response actions.~~	~~May be considered in remedial action due to the human health risks associated with ROCs at the Ballard Mine. Guidance documents can only be TBC.~~	~~TBC~~
~~9~~	~~DOE Licensing Requirements for Land Disposal of Radioactive Waste~~	~~10 C.F.R. § 61.41~~	~~Specifies annual dose of radioactive material that may be released to the general environment in several media.~~	~~Applicable to parties responsible for disposing of LLW received from other persons.~~ ~~Risk assessment utilizes ROC exposure concentrations instead of dose. May be considered in remedial action due to the human health risks associated with ROCs.~~	~~TBC~~
	~~Clean Air Act— National Emission Standards for Hazardous Air Pollutants (NESHAPs)~~	~~40 C.F.R. Part 61, Subparts H and I~~	~~Subparts H and I include radionuclide emission standards for Department of Energy and from other Federal facilities.~~	~~*We have deleted this section because the Site is not a federal facility and is not licensed by NRC.*~~ ~~*Subpart H - Applicable only to sites owned/operated by DOE; may be relevant and appropriate to federally-licensed NRC facilities.*~~ ~~*Subpart I - Applicable only to federal facilities not owned or operated by DOE and not licensed by NRC.*~~	

Commented [A4]: 40CFR 257 added to Table 3-3 in response to EPA SC#6

Commented [A5]: Deleted per EPA SC#5

Commented [A6]: Revised per EPA SC#1

Commented [A7]: Deleted per EPA SC#2 as cleanup decisions will be based on site-specific risk-based cleanup levels or background.

Commented [A8]: Deleted per EPA SC#2

Commented [A9]: Deleted per EPA SC#2

Table 3-2: State Chemical Specific ARARs for the Ballard Site

	Statutes, Regulations, Standards, or Requirements	Citations or References	General Description	Site-Specific Comments	Determination
1	Idaho Water Quality Standards	IDAPA 58.01.02	Surface water quality standards and waste water treatment requirements, including: water quality criteria for aquatic life use designations (.250), designations of surface waters found within Blackfoot Basin (.150), general surface water quality criteria (.200), antidegredation policy (.051), and mixing zone policy (.060).	Water quality standards are potentially applicable for surface waters on-Site or affected by the selected remedy. COCs/COECs and proposed surface water cleanup levels are provide in Table 3-6.	Applicable
2	Idaho Ground Water Quality Rule	IDAPA 58.01.11.200	Protects groundwater for beneficial uses including potable water supplies, establishes use classifications, and establishes water quality criteria for ground water.	Applicable to groundwater at the Site. COCs/COECs and proposed groundwater cleanup levels are provide in Table 3-6.	Applicable
3	Idaho Rules for Public Drinking Water Systems	IDAPA 58.01.08	Regulates quality and safety of public drinking water.	Potentially applicable if any of the Site water is a public drinking water source; otherwise, substantive requirements would likely be relevant and appropriate.	Potentially applicable and/or relevant and appropriate
4	Rules and Standards for Hazardous Waste	IDAPA 58.01.05	Rules and standards for hazardous waste. Identifies characteristic and listed hazardous wastes and provides rules for hazardous waste permits.	Potentially relevant and appropriate if hazardous waste is identified or generated during implementation of the selected remedy.	Potentially relevant and appropriate
5	Rules for the Control of Air Pollution	IDAPA 58.01.01 (including IDAPA 58.01.01.650 and .651)	Rules providing for the control of air pollution in Idaho.	Potentially applicable depending on the selected remedy.	Potentially applicable
~~6~~	~~IDEQ Area Wide Risk Management Plan~~	~~IDEQ (2004a)~~	~~Recommends removal action goals and action levels for addressing releases and impacts from historical phosphate mining operations in southeast Idaho.~~	~~May be taken into consideration in developing risk-based cleanup levels.~~	~~TBC~~

Commented [A10]: Revised per EPA SC#4

Commented [A11]: Revised per EPA SC#3

Commented [A12]: Deleted per EPA SC#7

Table 3-3: Federal Location and Action Specific ARARs for the Ballard Site

	Statutes, Regulations, Standards, or Requirements	Citations or References	General Description	Site-Specific Comments	Determination	Location or Action Specific
1	Mineral Leasing Act	30 U.S.C. §§ 181 *et seq.* 43 C.F.R. Parts 3500~~, 3580~~ and 3590	Regulates leasing, mining, processing and reclamation of federally-owned phosphate deposits. ~~Prevents unnecessary or undue degradation of public lands by operations authorized by the mining laws.~~	Provisions regarding reclamation and mineral development are potentially applicable; other provisions may be relevant and appropriate.	Applicable	Action, Location
2	Federal Land Policy and Management Act	43 U.S.C. §§ 17~~01~~32 *et seq.* ~~43 C.F.R. § 1600 *et seq.*~~.	Prevents unnecessary or undue degradation of public lands by operations authorized by the mining laws. Establishes public land policy and guidelines for the administration of public lands; provides for the management, ~~protection~~use, occupancy, and development~~, and enhancement~~ of public lands.	Provisions regarding multiple use and unnecessary or undue degradation~~ mineral development~~ are ~~potentially~~ applicable to the extraction of minerals; other provisions may be relevant and appropriate.	Applicable	Action, Location
3	U.S. Bureau of Land Management Record of Decision and Pocatello Resource Management Plan (April 2012), as amended Sept. 21, 2015	Available online at https://eplanning.blm.gov/epl-front-office/projects/nepa/32803/38812/40712/RODandSIR_508.pdf	To sustain the health, diversity, and productivity of the public lands. The plan provides objectives, land use allocations, and management direction to maintain, improve or restore resource conditions and provide for the economic needs of local communities over the long term. The plan applies to BLM-managed public lands and split estate lands where minerals are federally owned in southeast Idaho.	Should be considered due to BLM's ownership of the mineral rights.	TBC	Action, Location
4	Mine and Reclamation Plans		Operation plans that are approved subsequent to issuing the lease at a time after mining is proposed. Establish mine plans and reclamation requirements.	Should be considered during remedial action, especially if the remedy involves ore recovery.	TBC	Action, Location
~~6~~5	Fish and Wildlife Coordination Act	16 U.S.C. § 661 *et seq.*	Requires that federal agencies involved in actions that will result in control or modification of any natural stream or water body must protect fish and wildlife resources that may be affected by the actions.	Potentially applicable if remedial actions affect natural streams and water bodies; the selected remedy must be designed and implemented to be protective of fish and wildlife.	Applicable	Location
6	Endangered Species Act	16 U.S.C. §§ 1531 *et seq.* 50 C.F.R. Part 402	Federal Agencies are prohibited from jeopardizing threatened and endangered species or adversely modifying habitats essential to their survival. Requires consultation with the Service charged with protection of the listed species.	May be applicable if on-Site activities may jeopardize threatened or endangered species or adversely modify their habitat.	Applicable	Location (habitat), Action (species)
7	Migratory Bird Treaty Act (MBTA)	16 U.S.C. §§ 703 *et seq.*	Prohibits persons from pursuing, hunting, taking, capturing, killing, attempting to take, capture or kill, possessing, offering for sale, selling, offering to purchase, purchasing, delivering for shipment, shipping, causing to be shipped, delivering for transportation, transporting, causing to be transported, carrying, or causing to be carried by any means whatever, receiving for shipment, transportation or carriage, or exporting migratory	Remedial action at the Site must be designed and implemented to avoid harm to migratory birds.	Applicable	Action

Commented [A13]: Revised from draft

Commented [A15]: Provided citation/reference per EPA SC#8

Commented [A14]: Edits comport with FLPMA per EPA SC#8

Table 3-3: Federal Location and Action Specific ARARs for the Ballard Site						
	Statutes, Regulations, Standards, or Requirements	**Citations or References**	**General Description**	**Site-Specific Comments**	**Determination**	**Location or Action Specific**
			birds covered by the MBTA or any part, nest, or egg of any such bird.			
8	Bald and Golden Eagle Protection Act	16 U.S.C. §§ 668 *et seq.* 50 C.F.R. Part 22	Prohibits any person from knowingly, or with wanton disregard, selling, offering to sell, taking, purchasing, transferring, bartering, exporting, importing, or possessing or harming a bald or golden eagle, or any part, nest, or egg thereof without obtaining a permit.	Remedial action at the Site must be designed and implemented to avoid harm to bald or golden eagles, their nests, or eggs.	Applicable	Location, Action
9	Clean Water Act	40 C.F.R. § 125.3	Requirements for best treatment and control technology prior to discharge.	May be relevant and appropriate if water treatment is used as part of the selected remedy.	Potentially relevant and appropriate	Action
10		33 U.S.C. § 1342 40 C.F.R. Parts 122-125	The NPDES (also known as Section 402 of the CWA) program establishes a comprehensive framework for addressing waste water and storm water discharges under the program. Requires that point-source discharges not cause the exceedance of surface water quality standards outside the mixing zone. Specifies requirements under 40 C.F.R. § 122.26 for point-source discharge of storm water from construction sites to surface water and provides for Best Management Practices such as erosion control for removal and management of sediment to prevent run-on and runoff.	May be relevant and appropriate if the selected remedy involves discharges from a water treatment plant.	Potentially relevant and appropriate	Action
11		33 U.S.C. § 1344	Requirements for dredging and filling activities conducted in waters of the U.S., including wetlands (also known as Section 404 of the CWA).	May be relevant and appropriate if the selected remedy involves dredging or filling in waters of the U.S.	Potentially relevant and appropriate	Location, Action
12	Clean Air Act	42 U.S.C. §§ 7409 *et seq.* 40 C.F.R. Part 50	Requirements for maintaining air quality.	Potentially applicable depending on the selected remedy.	Potentially applicable	Action
13	National Historic Preservation Act (NHPA)	~~16 U.S.C. §§ 470f~~ 54 USC 306108 36 C.F.R. Parts 60, 63 and 800	A requirement for a property listed on or eligible for listing on the National Register of Historic Places. The NHPA requires federally funded projects to identify and mitigate impacts of project activities on properties listed on or eligible for listing on the National Register. This statute and implementing regulations require federal agencies to take into account the effect of this response action upon any district, site, building, structure, or object that is listed on or eligible for listing on the National Register of Historic Places (generally, 50 years old or older).	May be applicable if historic or archeological sites are found within Site boundaries or on land to be disturbed in connection with the selected remedy (*e.g.*, borrow areas).	Potentially applicable	Location

Commented [A16]: Revised from draft

Commented [A17]: This statute was repealed in 12/2014 and re-codified. Missed in the draft.

Table 3-3: Federal Location and Action Specific ARARs for the Ballard Site						
	Statutes, Regulations, Standards, or Requirements	**Citations or References**	**General Description**	**Site-Specific Comments**	**Determination**	**Location or Action Specific**
			If cultural resources listed on or eligible for listing on the National Register are present, it will be necessary to determine if there will be an adverse effect and, if so, how the effect may be minimized or mitigated, in consultation with the appropriate State Historic Preservation Office.			
14	Archeological and Historic Preservation Act	~~16 U.S.C. § 469~~ 52 USC 312501 et seq.	The Archaeological and Historic Preservation Act requires that for federally approved projects that may cause irreparable loss to significant scientific, prehistoric, historic, or archaeological data, the data must be preserved by the agency undertaking the project or the agency undertaking the project may request DOI to do so. This statute and implementing regulations establish requirements for the evaluation and preservation of historical and archaeological data, which may be destroyed through alteration of terrain as a result of a federal construction project or a federally licensed activity or program.	May be applicable if archeological resources are identified.	Potentially applicable	Location
	~~Native American Graves Protection and Repatriation Act (NAGPRA)~~	~~25 U.S.C. §§ 3001 *et seq.*~~	~~Requires federal agencies and institutions that receive federal funding to return Native American cultural items to lineal descendants and culturally affiliated Indian tribes. NAGPRA also establishes procedures for the inadvertent discovery or planned excavation of Native American cultural items on federal or tribal lands.~~	*We deleted this requirement because P4 is not a federal agency or institution and because the Site boundaries do not include federal or tribal lands. However, this act will be reconsidered at the other P4 CERCLA Sites where federal land was leased.*		~~Location~~
15	RCRA— Requirements for Hazardous Waste Transport	42 U.S.C. §§ 6901 *et seq.* 40 C.F.R. Parts 261-262	Requirements for handling and transporting hazardous waste.	Potentially relevant and appropriate depending on selected remedy.	Potentially relevant and appropriate	Action
16	RCRA – Requirements for Classification of Solid Waste Disposal Facilities	40 C.F.R. Part 257	Requirements for solid waste disposal facilities and practices, such as restrictions to the base flow of a flood plain, not taking threatened and endangered species, and not causing a discharge to navigable waters.	Potentially relevant and appropriate depending on selected remedy.	Potentially relevant and appropriate	
~~16~~17	Considering Wetlands at CERCLA Sites	OSWER 9280.03, May 1994	EPA guidance regarding the potential impacts of response actions on wetlands at Superfund sites.	May be helpful if Site remediation contains wetlands.	TBC	Action

Commented [A18]: Omitted from USC in 2014; recodified. Missed in the draft.

Commented [A19]: We disagree with EPA SC#9 and do not believe this regulation is potentially RAR for the Ballard Site.

Commented [A20]: Added per EPA SC#6. 40 CRF 258 is not included, refer to P4's response to SC#6

Table 3-4: State Location and Action Specific ARARs for the Ballard Site						
	Statutes, Regulations, Standards, or Requirements	**Citations or References**	**General Description**	**Site-Specific Comments**	**Determination**	**Location or Action Specific**
1	Protection of Birds	Idaho Code Ann. § 36-1102	Prohibits the "take" or intentional disturbance or destruction of eggs or nests of any "game, song, rodent killing, insectivorous or other innocent bird." The prohibition does not apply to English Sparrows or starlings.	Potentially applicable during remedial action.	Potentially applicable	Action
2	Non-point Source Discharges	IDAPA 58.01.02.350	Regulates non-point source discharges, designates approved BMPs and provides additional protection for outstanding resource waters.	May be applicable if the selected remedy results in non-point source discharges.	Potentially applicable	Action
3	Point Source Discharges	IDAPA 58.01.02.400-.401	Provides limits and restrictions including possible limits on temperature and flow rates for point source discharges.	May be applicable if the selected remedy results in point source discharges.	Potentially applicable	Action
4	Storage of Hazardous and Deleterious Materials	IDAPA 58.01.02.800	Prohibits the storage, disposal or accumulation of hazardous and deleterious materials "adjacent to or in the immediate vicinity of state waters" without adequate measures and controls to insure the materials will not enter state waters.	May be relevant and appropriate if the remedial action results in the storage of hazardous and deleterious materials near state waters.	Potentially relevant and appropriate	Action
5	Well Construction Standard Rules	IDAPA 37.03.09	Regulates well construction and abandonment.	May be applicable if the selected remedy includes additional wells.	Potentially applicable	Action
6	Best Management Practices and Reclamation for Surface Mining Operations	IDAPA 20.03.02.140	Provides BMP and reclamation standards for surface mining operations, including sand and gravel mining.	May be applicable depending on the selected remedy. BMPs may also be relevant and appropriate to remediation activities (i.e. grading, re-contouring, and revegetation).	Potentially applicable and/or relevant and appropriate	Action
7	Idaho Water Quality Standards and Wastewater Treatment Requirements	IDAPA 58.01.02	Requirements for actions involving effluent discharges to surface water.	May be applicable if water treatment is part of the selected remedy.	Potentially applicable	Action
8	Solid Waste Management Rules	IDAPA 58.01.06	Provides substantive requirements for operation and closure of solid waste management facilities.	Only material uniquely associated with phosphate mining is being addressed in the remediation so these requirements are not applicable because the Site is not a solid waste management facility. See IDAPA 58.01.06.001.03(b)(iv). Some requirements may be relevant and appropriate with regard to regulated solid waste generated during the remedial action.	Potentially relevant and appropriate	Action
9	Hazardous Waste and Hazardous Waste Management Act of 1983	IDAPA 58.01.05 1993 Session Law, Ch. 291, Sections 1-8	Adopts federal RCRA regulations concerning the identification of hazardous waste and standards applicable to generators and transporters of hazardous waste as well as	Potentially applicable for management of investigation derived wastes and remediation wastes.	Potentially applicable	Action

Table 3-4: State Location and Action Specific ARARs for the Ballard Site						
	Statutes, Regulations, Standards, or Requirements	**Citations or References**	**General Description**	**Site-Specific Comments**	**Determination**	**Location or Action Specific**
			standards for owners and operators of hazardous waste treatment, storage and disposal facilities.			
10	Fences in General (LEAs)	Idaho Code §§ 35-101 to -112	Establishes construction requirements, such as height and distance between posts, for all types of fences. Defines who is responsible for construction and maintenance of enclosure and partition fences.	May be applicable if fencing is required to protect components of the selected remedy (e.g., a cover system).	Potentially applicable	Action
11	Idaho Rules for Control of Fugitive Dust	IDAPA 58.01.01.650-651	Provides practices for controlling fugitive dust emissions, including use of water or chemicals, application of dust suppressant, and covering trucks.	May be applicable during remedial action if construction practices generate fugitive dust.	Potentially applicable	Action
12	Idaho Toxic Air Pollutants	IDAPA 58.01.01.585-586	Requirements for maintaining air quality (none currently nor will they be likely associated with any remedial action).	Potentially applicable depending on the selected remedy.	Potentially applicable	Action
13	Preservation of Historical Sites	Idaho Code §§ 67-4111 to -4131 and 67-4601 to -4619	Requirements for protection of public lands and preservation of historical or archaeological sites in consideration of waste disposal.	Requirements may be applicable if historical or archeological sites are present and/or may be disturbed during the remedial action.	Potentially applicable	Location
14	Stream Channel Alteration Rules	IDAPA 37.03.07.055	Provides substantive construction standards for working in stream channels.	Potentially applicable depending on selected remedy; however, procedural requirements are not ARAR.	Potentially applicable	Action
15	Idaho Classification and Protection of Wildlife Rule	IDAPA 13.01.06.300	Classifies fish and wildlife species; identifies threatened or endangered species; and specifies wildlife species that are protected from taking and possessing.	To be considered during ecological risk assessment.	TBC	Location
16	Idaho Uniform Environmental Covenants Act	Idaho Code §§55-3001 to -3015	Allows recordation of an environmental covenant, which is a written agreement where the parties bind themselves, and their successors in interest to the land, to comply with activity and use limitations.		Applicable	Action
17	IDEQ Area Wide Risk Management Plan	IDEQ (2004a)	Recommends removal action goals ~~and action levels~~ for addressing releases and impacts from historical phosphate mining operations in southeast Idaho.	May be taken into consideration in developing ~~risk-based cleanup levels~~removal action goals.	TBC	Action
18	Variances from water quality standards	IDAPA 58.01.02.260	Establishes procedures and requirements for obtaining a water quality variance.	Potentially applicable if Site-specific variances are proposed for a particular location or source.	Potentially applicable	Action
19	Idaho Risk Evaluation Manual	IDEQ (2004b) Available online at https://www.deq.idaho.gov/media/967298-risk_evaluation_manual_2004.pdf	Provides guidelines and criteria to apply in risk-based decision making.	Framework for decision making should be considered in developing human and environmental risk-based cleanup levels	TBC	Action

Commented [A21]: Revised per EPA SC#7.

APPENDIX C-10

A/T Supplemental Comments on P4 Response to Comments on Ballard ARARs (dated March 9, 2016)

Transmitted to P4 on March 22, 2016

Leah Wolf Martin

From:	Tomten, Dave <Tomten.Dave@epa.gov>
Sent:	Tuesday, March 22, 2016 1:22 PM
To:	Vance Drain; Vidargas, Nick
Cc:	MOLLY PRICKETT [AG/1850]; Leah Wolf-Martin (leah@wolfmartininc.com); COOPER, RANDALL LEE [AG/1000]; Barry Myers (bmyers@blm.gov); Bruce Olenick; Colleen O'Hara-Epperly; Dennis Smith (dennis.smith2@ch2m.com); Edmond, Lorraine; Eldine Stevens; Gary Billman; Jeff Cundick; Jeff Schut; Jeremy Moore (jeremy_n_moore@fws.gov); Kelly Wright; Michael Rowe; Norka Paden (Norka.Paden@deq.idaho.gov); Sandi Fisher; Shannon Leigh Ansley (sansley@sbtribes.com); Shephard, Burt; Stifelman, Marc; Stumbo, Sherri A -FS; susanh@ida.net; Tomten, Dave; Trina Burgin; Wallace, Joe
Subject:	RE: Revised ARAR Tables 3-1 to 3-4 and RTCs

Molly, all –
We reviewed the recent responses to comments on outstanding ARARs issues for the Ballard site. We agree with all responses, except for portions of the response to specific comment #9, which pertains to the Native American Graves Protection and Repatriation Act (NAGPRA). While we agree that this act is not *applicable* at Ballard due to land ownership considerations, it is potentially relevant and appropriate as those terms are defined, and thus should be identified as *potentially* relevant and appropriate in the FS. Although the likelihood of encountering artifacts or gravesites at the previously disturbed Ballard mine site may be low, NAGPRA, combined with the Archeological and Historical Preservation Act will serve to protect tribal interests during implementation of remedial actions at Ballard. Resolution of these remaining ARARs issues should allow for completion and approval of technical memo #1 (the first half of the FS). We would be pleased to further discuss this matter (or identification of other potential ARARs) prior to preparation of the ROD, where the final selection of ARARs will be presented.

Please let me know if you have any remaining questions or concerns.
Dave

From: Vance Drain [mailto:Vance.K.Drain@mwhglobal.com]
Sent: Wednesday, March 09, 2016 8:15 AM
To: Tomten, Dave <Tomten.Dave@epa.gov>
Cc: MOLLY PRICKETT [AG/1850] <molly.prickett@monsanto.com>; Leah Wolf-Martin (leah@wolfmartininc.com) <leah@wolfmartininc.com>; COOPER, RANDALL LEE [AG/1000] <randall.lee.cooper@monsanto.com>
Subject: Revised ARAR Tables 3-1 to 3-4 and RTCs

Hi Dave,
Attached are P4's responses to A/T comments (dated February 17, 2016) on the revised ARAR table that we originally sent to you on 7/30/15.
Please distribute this document to the other A/Ts, and let us know if you have any questions with regard to our responses or the revised ARAR tables (second revision).
Best Regards,
Vance

MWH GLOBAL
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Salt Lake City, UT 84121

(801) 617 3250 (work), (801) 831 4059 (cell)

APPENDIX C-11

A/T Conditional Approval of Ballard Mine Feasibility Study Report, Memorandum 1, Site Background and Screening of Technologies, Draft Final Revision 1, March 2016

Transmitted to P4 on April 14, 2016

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
IDAHO OPERATIONS OFFICE
950 West Bannock, Suite 900
Boise, Idaho 83702

April 14, 2016

Molly R. Prickett
Environmental Engineer
Monsanto Company
Soda Springs Operations
1853 Highway 34
Soda Springs, Idaho 83276

Re: Conditional Approval of Ballard Mine Feasibility Study Report, Memorandum 1, Site Background and Screening of Technologies, Draft Final Revision 1, March 2016

Dear Ms. Prickett,

The Agencies and Tribes (A/T) have reviewed the above referenced deliverable, submitted pursuant to the Administrative Settlement Agreement and Order on Consent/Consent Order for Performance of Remedial Investigation and Feasibility Study at the Enoch, Henry, and Ballard Mine Sites in Southeastern Idaho (or 2009 AOC). We have reviewed this document to ensure that the revised document responds to and incorporates changes agreed to during the response to comment process. In conducting our final review, we have identified the following issues to be addressed in the final.

- Section 1.3.1, page 1-4 of RL-SO version. The narrative states that the contamination of the Ballard Shop Area will be addressed in the future when the facility is no longer in use, and is therefore not addressed in the FS. Delete the phrase "… and it is not addressed in this FS." We agree that remediation of the shop area may be deferred while that area is being used in the future. Discussion of the shop area should, however, be carried into FS tech memo #2. The FS TM#2 should briefly describe actions necessary, including ICs, to maintain protectiveness for the existing industrial use. TM #2 should also describe approaches for final remediation, including ICs, for this area to meet PRAOs. This will ensure that future cleanup work at this small portion of the Ballard site is tracked along with the other elements of the project.

- Section 2.1, 2nd paragraph, 3rd sentence: Revise sentence to read "and is enriched with COCs/ROCs/COECs which includes metals, metalloids, naturally occurring uranium, and uranium-daughter products (e.g., radium-226 and radon-222).

- Section 3.5, page 3-5 of RL-SO version. According to Table 3-7, background antimony concentration for upland soil is 3.6 mg/kg not 0.745 mg/kg as stated here.

- Section 4.3.2, page 4-13 of RL-SO version, paragraph 1 (partial), line 9. Change "created" to "create."

As these are minor issues, I am providing conditional approval the deliverable. Please proceed with issuing a final version and distribute to the agencies and tribes. Please contact me if you have questions. I can be reached at 208-378-5763 or electronically at tomten.dave@epa.gov.

Sincerely,

//s//

Dave Tomten
Remedial Project Manager

cc: Mike Rowe, IDEQ - Pocatello
Jeremy Moore, US FWS – Chubbuck
Kelly Wright, Shoshone Bannock Tribes
Shannon Ansley, Shoshone Bannock Tribes (electronic version only)
Sandi Fisher, US FWS – Chubbuck (electronic version only)
Sherri Stumbo, Forest Service – Pocatello (electronic version only)
Colleen O'Hara-Epperly, BLM – Pocatello (electronic version only)
Barry Myers, BLM – Pocatello (electronic version only)
Vance Drain, MWH (electronic version only)
Cary Faulk, Integrated-Geosolutions (electronic version only)
Dennis Smith, CH2MHill (electronic version only)
Gary Billman, IDL – Pocatello (electronic version only)

APPENDIX C-12

P4 Response to A/T Conditional Approval letter (dated April 14, 2016) on Ballard FS Memo #1 Draft Final Revision 1

Submitted to A/T on May 2, 2016

P4's Responses to A/T Conditional Approval Letter dated April 14, 2016

on the

Feasibility Study Technical Memorandum for P4's Ballard Mine Draft Final Revision 1, March 2016

Specific Comments

SC#1. Section 1.3.1, page 1-4 of RL-SO version. The narrative states that the contamination of the Ballard Shop Area will be addressed in the future when the facility is no longer in use, and is therefore not addressed in the FS. Delete the phrase "… and it is not addressed in this FS." We agree that remediation of the shop area may be deferred while that area is being used in the future. Discussion of the shop area should, however, be carried into FS tech memo #2. The FS TM#2 should briefly describe actions necessary, including ICs, to maintain protectiveness for the existing industrial use. TM #2 should also describe approaches for final remediation, including ICs, for this area to meet PRAOs. This will ensure that future cleanup work at this small portion of the Ballard site is tracked along with the other elements of the project.

- ***P4 Response (SC#1):*** *P4 proposes that a separate closure plan be developed for the Ballard Shop Area that includes: 1) the Ballard Shop background, i.e., the nature and extent of contamination and technologies suitable for remediation of the Shop constituents, 2) plans for control of risks to industrial workers during future industrial use of the area prior to final closure, 3) plans for control of any ongoing contamination from source area(s) identified at the Shop and 4) plans for final closure of the Ballard Shop when the Shop is no longer used.*

  Reference to this closure plan will be included in FS Memos #1 and #2 and the closure plan will be transmitted prior to the finalization of FS Memo #2 so that the Ballard Shop can be included in the ROD for the overall Site.

SC#2. Section 2.1, 2nd paragraph, 3rd sentence: Revise sentence to read "and is enriched with COCs/ROCs/COECs which includes metals, metalloids, naturally occurring uranium, and uranium daughter products (e.g., radium-226 and radon-222).

P4 Response (SC#2)*: Agreed. This revision has been incorporated into the final document.*

SC#3. Section 3.5, page 3-5 of RL-SO version. According to Table 3-7, background antimony concentration for upland soil is 3.6 mg/kg not 0.745 mg/kg as stated here.

P4 Response (SC#3)*: The value of 3.6 mg/kg in Table 3-7 is the correct current background value for antimony in upland soil based on the 2014 background investigation. The text in Section 3.5 has been revised to include the current background value.*

SC#4. Section 4.3.2, page 4-13 of RL-SO version, paragraph 1 (partial), line 9. Change "created" to "create."

P4 Response (SC#4)*: Agreed. This revision has been incorporated into the final document.*